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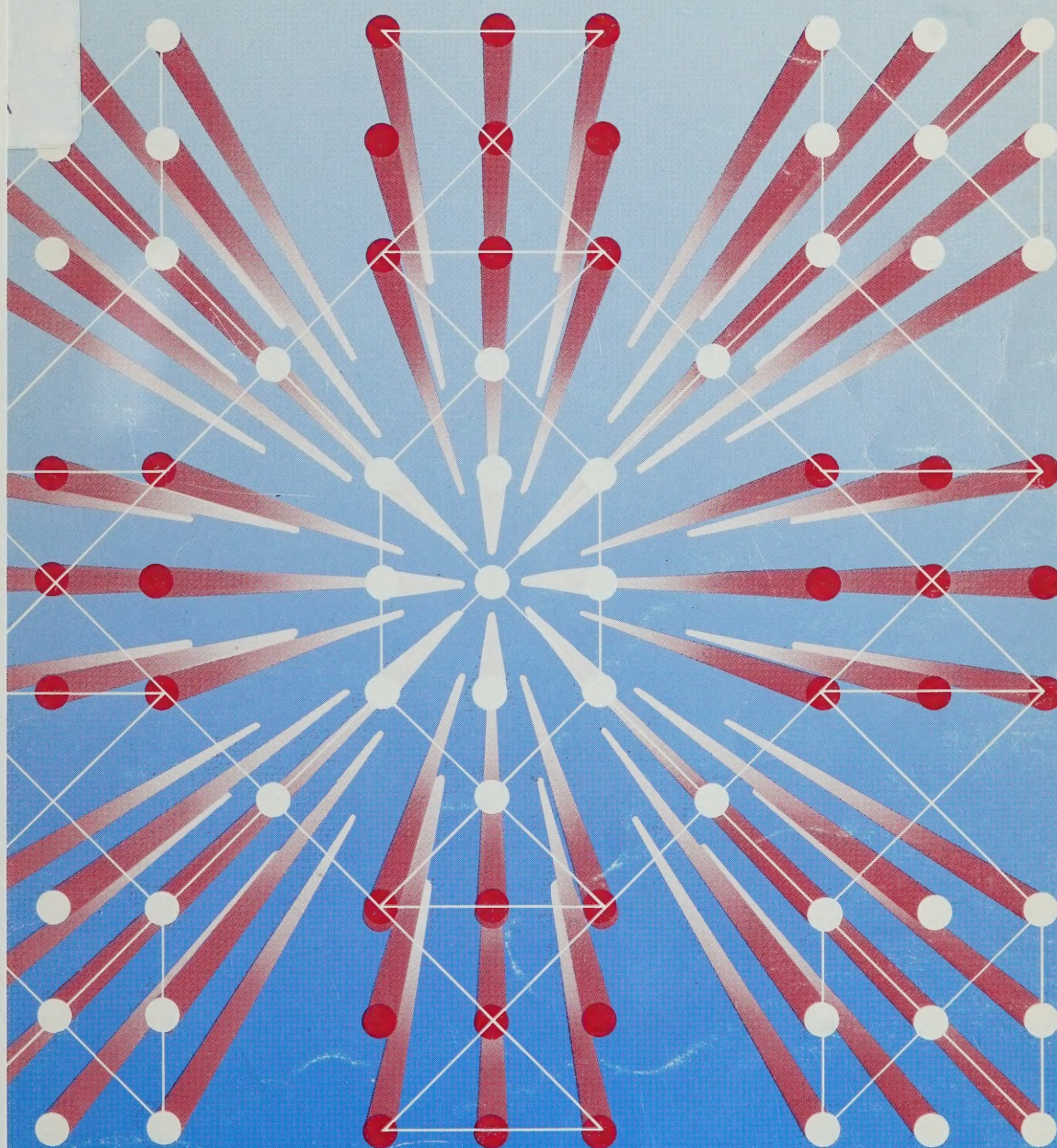
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Indicator of Excellence Canadian Science

James B. MacAulay



Canada



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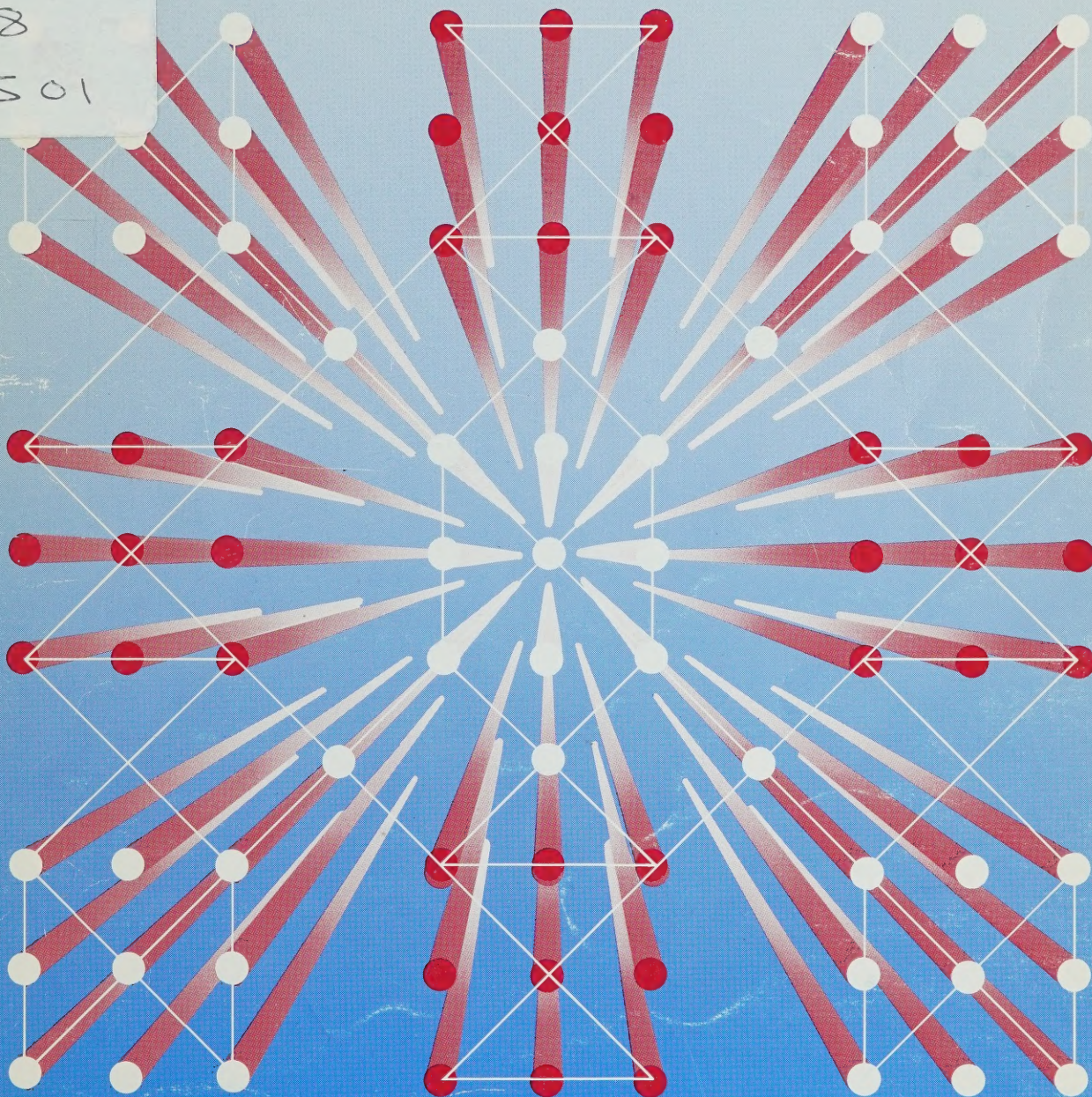
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An Indicator of Excellence in Canadian Science

by James B. MacAulay

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An Indicator of Excellence in Canadian Science

by James B. MacAulay

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- .. figures not available.
- ... figures not appropriate or not applicable.
- nil or zero.
- amount too small to be expressed.
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PREFACE

This paper describes the theory of a bibliometric analysis, outlines the limitations of a citation index to papers and journals, and presents selected results of a pilot project in bibliometrics involving an evaluation of the research papers and journals monitored by the Institute for Scientific Information. An overview of the above topics is contained in an earlier publication, **An Indicator of Excellence in Canadian Science: Summary Report**, Catalogue No. 88-507E.

Science and technology indicators may be defined as statistics which measure quantifiable aspects of the creation, dissemination and application of science and technology. As indicators, they should help to describe the science and technology system, enabling better understanding of its structure, of the impact of policies and programs on it, and the impact of science and technology on society and the economy.

An Indicator of Excellence in Canadian Science is one of a series of background papers on science and technology indicators published by Statistics Canada. The purpose of the series is to describe the theoretical development, limitations and application of various statistics suggested as indicators of science and technology.

Current indicators of Canada's scientific and technological activities include:

- . expenditures on research and development;
- . federal government scientific activities;
- . personnel working in science and technology;
- . Canadian research output (citations);
- . Canadian patented inventions;
- . international payments and receipts for technology;
- . trade in selected commodities.

Statistical tabulations of the indicators will be released in **Science and Technology Indicators**, Catalogue No. 88-201, an annual summary; **Industrial Research and Development Statistics**, Catalogue No. 88-202 (annual); **Resources for Research and Development in Canada**, Catalogue No. 88-203 (annual); **Federal Scientific Activities**, Catalogue No. 88-204E (annual); and in a monthly service bulletin, **Science Statistics**, Catalogue No. 88-001.

A list of the background papers is included at the end of this publication. These papers represent the opinions of the authors and do not necessarily represent those of Statistics Canada. Comments are invited and should be addressed to Humphrey Stead of the Science and Technology Statistics Division.

This paper has been prepared by James MacAulay of the Information Analysis Group and edited by Karen Walker and Elizabeth MacKenzie.

Martin B. Wilk,
Chief Statistician of Canada.



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Several individuals have been involved at various stages of this study, which is essentially a pilot project on the bibliometric analysis and evaluation of research. Dr. Charles Colbourn and Dr. Marlene Colbourn, both of the Computer Science Department at the University of Waterloo, along with Mr. Michael Whitehead, collaborated with the author in developing a computer algorithm for the solution of the clustering problem. Dr. Kwong Chiu Lam and Mr. Wan Hay Wong carried out most of the computer implementation, while the location dictionaries were prepared by Mr. Larry Sullivan and Mr. Shawn Brennan at the Science Council of Canada. The Canada Institute for Scientific and Technical Information assisted in several ways, and shared the computer costs of an initial feasibility study. The methodology was developed by the author as part of a project for the Complex Systems Institute, Case Western Reserve University (NSF:GN-36085), under the direction of Dean William Goffman. The large-scale implementation reported here was carried out at the Science Council of Canada as part of the activities of its Task Force on Research. The author gratefully acknowledges the courage of the Science and Technology Statistics Division of Statistics Canada in publishing the results of a study which represents a significant, and some will say radical, departure from the routine procedures for evaluating the quality of research.

INTRODUCTION

This paper reports on a bibliometric study of the literature of science and technology. The purpose of the study was to develop a family of indicators to measure the results of research activities, and to evaluate their contribution to the science community. Such an undertaking was bound to be controversial because the evaluation of scientific literature has traditionally been left to the internal processes of judgment by one's peers. The methodology developed and implemented in the study however, uses publication and citation data, artifacts of the peer judgment process.

While the pilot study described here was carried out in 1979 and 1980, there has been a long delay in publishing the results since they caused considerable controversy. The intervening time has been used to undertake a series of evaluations. The delay has been advantageous: time has proven that the objective procedure described here selected precisely the paper (among millions) which initiated a revolution in research areas throughout biochemistry and medicine.

For several reasons existing classifications of the system of journals are unsatisfactory (e.g., subjective selection); a by-product of this study is the first systematic evaluation and clustering of journals and papers representing the whole of science. The structure of the journal system is reported only as it refers to the classification of journals, but additional avenues have been opened into the sociology and dynamics of science and technology as a system of knowledge.[1]

The typical statistical distributions in this field are very skewed, and therefore, familiar descriptive measures, such as averages that are based on central tendency assumptions, would have been misleading. Technical measures have been kept to a minimum, and as far as possible, a sequence of the same measures is repeated for all research areas. Appendices IV and VI have been organized with cross-references to assist the reader to access the results from any starting point such as a particular journal or area of interest.

Chapter 1 describes the theoretical aspects of a bibliometric analysis. The difficulties in using available data are examined and the publications collection of the Institute for Scientific Information (ISI) is assessed; the final section of Chapter 1 outlines an "analysis of relevance" which forms the basis of our study. Chapter 2 presents the results of a classification of the ISI journals followed by a presentation of descriptive indicators of the papers within these journals. Chapter 3 focuses on the evaluative assessment of international performances in various research activities, and concludes with a specific examination of Canada's contribution to the literature of science. The results of the study are summarized in Chapter 4.

See References at end of text.

Chapter 1

THE DEVELOPMENT OF A BIBLIOMETRIC STUDY

Introduction

For any analysis of science a key issue is how to define the subject of study. Within the science community, one can identify a variety of different sources of information including professional scientists and associations circulating old science or generating new science. This community is supported by institutional resources and facilities, technically competent individuals, as well as libraries filled with reference literature. It is reasonable to suggest that a common focus for all members of this community is scientific and technical knowledge. And, it follows, that knowledge, or more correctly, intellectual property must be one of its most crucial possessions: the element that animates and motivates all its members. Scientific publication functions as a communication system within the community such that contributions to scientific knowledge can be circulated and acknowledged, and thus attain to their value.

In Appendix I the relationship between science and the literature of science is discussed. The formal use of published accounts of research to establish priority claims to knowledge, i.e., intellectual property, is put into historical context. We see that the research paper has become the chief tool for making priority claims in intellectual property and for having such claims evaluated by peers.[2]

Judgment by one's scientific peers would seem to be a process that takes place in at least two stages. Peers initially appear in the somewhat elite form of gatekeepers: evaluating proposals, reviewing accomplishments for tenure and other awards, and editorial refereeing of papers. The second stage of peer evaluation is definitely more democratic. Publication is essentially a knowledge claim which calls for recognition by the entire scientific community for the author's priority in the discovery of new knowledge.[3] One of the most common responses is the citation. The citation is of special interest because, while it can be used in both pejorative and substantive ways, it is at all times a formal and objective record by the scientific community at large which recognizes the knowledge claims of others, and which represents an evaluation of these claims. Publication and citation therefore, can be taken to represent declarations of achievement and recognition respectively.

The discipline of bibliometrics makes use of the fact that knowledge must be documented in order to be formally communicated, making it possible to develop measures of selected characteristics of the records and/or documents generated in this process. The purpose of a bibliometric analysis is to derive measurable variables from a system of documentation that are characteristic of the scientific knowledge represented therein, and of the research community in which it is to be circulated. The purpose of the analysis here is to derive a family of indicators that are descriptive of trends in the direction and levels of activity within science, and evaluative with respect to the quality and relevance of that output; and more specifically, to derive indicators of excellence in Canadian science.

Such bibliometric indicators provide useful information for the consideration of science policy issues at both national and organizational levels, and for testing hypotheses which arise from the social studies of science. Applications of the latter type stress an analysis of the structure and dynamics of research areas. We are concerned here with policy-relevant indicators which have a different emphasis - the identification of output trends and the quality of papers at national, sectoral and organizational levels.

The limitations of a bibliometric study including the possible sources of error which may affect such an analysis will now be reviewed.

Limitations

The first bibliometric exercises were intended as an aid to biblical scholarship. The "Concordantiae Morales", by tradition ascribed to Anthony of Padua (1195-1231), was a concordance of words, with

See References at end of text.

cited passages of their occurrence, from Scripture. In the thirteenth century, a Dominican Cardinal repeated the exercise using an older version of the Bible, and employing 500 of his brothers in the task.[4]

This tradition of scholarship was revived in the word frequency studies of G.K. Zipf in this century, and more recently in the field of type-token mathematics and psycholinguistics.[5] The Zipfian distribution of word frequencies has also been observed by A.J. Lotka with respect to the productivity of authors, and by S.C. Bradford in his studies of the distribution of papers on a subject among journals.[6]

These studies demonstrate that, under given conditions of use, the elements of an information source will exhibit high degrees of relatedness and interdependence, with relatively few of the elements satisfying most of the demand in a highly ordered and predictable fashion. The point is most obvious in studies of vocabulary use in texts where grammatical rules and subject requirements determine that words will not be selected independently; we shall return to this idea in developing a methodology for analysing "relevance" relations among source elements in the following section.

However, much of the current work in bibliometrics does not draw upon these and other developments in the field of information science (see Appendix II). As a result, one can find a number of bibliometric studies based upon the following unwarranted assumptions: information is objective and measurable; information can be measured as a flow from independent source elements to users; and the information source and its user population can be arbitrarily selected. The possible errors to which these assumptions can lead are divided into three types.

Errors derived from failing to take into account intrinsic characteristics of science and scientific literature. Examples of this type of error arise if one does not acknowledge the radical variations among disciplines in the production, citation behaviour, rate of self-citation as well as, variations in authorship characteristics.

One of the most fundamental characteristics of science and its literature is the very high degree of organization. Each discipline has its own history and institutions and, when inquiring within one's own field, one is on familiar ground. Disciplinary characteristics will strongly influence bibliometric exercises such as publication or citation counting. Within a subject literature which is well enough defined to be studied over a long time span, the average number of publications per author appears to remain constant, despite radical changes in the cognitive structure of the field and its population of investigators.[7] On the other hand, from one discipline to another, this productivity ratio varies radically. In turn, the number of citations and co-citations which might be expected from papers will vary among disciplines.

Editorial practices also vary considerably among disciplines. For example, page limitations will affect the number of references in a paper, and costs will presumably keep down the number of papers. Some fields maintain high rejection rates, which should elevate the quality of accepted publications, thus increasing the likelihood that published papers will be cited.

The norms of publishing and referencing behaviour must also reflect variations in both content and style as well. For example, referencing in the development of mathematical theorems will be sparse compared with that in review articles; and no doubt the frequency of self citations and negative references is a matter of normative constraint in at least some fields.[8] Team work prevails in many research areas, particularly those involving large-scale apparatus or remote locations. In turn, such factors as the numbers of co-authors and the ordering of co-authors on a paper, which is clearly a matter of style, must be taken under consideration.

Errors introduced by inherent limitations of particular methodologies. Much of the bibliometrics field has developed around techniques which contain unrealistic assumptions about scientific communication as a flow of information from source to user, representing these by publications and citations. These studies also reflect tendencies which prefer technique to theory, frequently using subjectively derived and grossly aggregated groups of journals to represent research areas. Journal groups that are too heterogeneous and ill defined do not allow the development of measures that might otherwise overcome the two other types of errors. To be sure, the great majority of bibliometric studies have indeed been conducted on a small scale, beginning with a bibliography of a subjectively confined research area, or generating a bibliography by building up collections of co-cited papers.[9] Many of the problems associated with the information source or data base (see below) are not apparent until these procedures are subsequently and uncritically adopted for general use.

Attempts at validating bibliometric results by correlating them with the more elitist forms of peer evaluation have proven quite encouraging as shown by the following examples of bibliometric exercises. Assuming that university departments represent roughly comparable fields of research, the

Roose-Anderson and Cartter assessments of graduate programs have in turn been correlated with simple bibliometric indicators of the same departments.[10] In his review of some 24 correlations of simple publication and citation indicators with evaluations involving the Roose-Anderson, Cartter and other non-bibliometric forms of peer evaluation, Francis Narin observed that, with respect to publications: "Peer evaluations have been found to correlate positively with citation rates, with the more highly cited publications generally more highly rated by the scientists' peers". Moreover, with respect to the evaluation of investigators: "In almost all cases, the bibliometric measures of eminence ascribed to groups of scientists will correlate reasonably well in the range of 0.5 to 0.8, with other eminence rankings". Finally, with respect to departments, "Most studies of this type show correlations in the 0.7 to 0.9 range".[11] The bibliometric measures used in these correlations represent simple citation counts with no attempt to overcome the sources of error discussed in this chapter.

With the strong correlations in favour of institutional-scale bibliometric indicators, Narin went on to develop, following Eugene Garfield, a weighted average impact factor for journals, based on the citations generated per reference made.[12] He then developed indicators of the departmental output at various universities, weighting it by the impact factor of journals, and found stronger correlations with Roose-Anderson than were found simply using publication output.[13] These encouraging results still require subjective groups of journals, and of course, they are not specific with respect to the quality of papers.

On the other hand, the work of Henry Small on co-citation analysis addressed itself specifically to the quality and clustering of papers. By commonly citing two or more source papers, an author not only recognizes their separate knowledge claims, but groups or indexes them together in a single account. Thus, in identifying frequently co-cited pairs of papers or authors, Dr. Small and others developed a technique which, given a threshold condition, could cluster elements in a small homogeneous source and at least draw attention to the more important linkages relative to others in a very small information source.[14] However, as an impact factor, it is still subject to the biases which follow from the possible errors listed, including self and prestige citing; and when normalized, the co-citation linkage is not directional.[15] This means that, for example, by citing oneself and Einstein frequently, one could easily appear to a co-citationist to be quite important and part of an inner circle in an unwarranted way. Moreover, co-citation measures must be carefully normalized before they can be generalized from one field to another.

Nevertheless, co-citation did shift attention from the essentially false notion that one can measure information flow, toward the more fruitful approach of measuring relations among documents. Myer Kessler had contributed by developing a method of bibliographic coupling which groups documents with similar bibliographies, as opposed to grouping those with similar citation files.[16] An influential paper by Professor de Solla Price also drew attention to the clustering of "networks" of cited papers, although in his calculations, he was concerned with network dynamics rather than with its internal structure, or an evaluation of its components.[17]

Errors derived from the character of the information source or data base. These include geographical, linguistic and disciplinary bias in the available sources of bibliometric data. Other factors to be taken into account include variations in editorial policy, on both a national and disciplinary basis, with respect to rejection rates and lengths of articles. This error type will be discussed in detail as the adequacy of the ISI data base is a central factor to be considered in the design of the pilot study.

The Institute for Scientific Information (ISI) provides valuable data for bibliometric studies. In 1978, ISI monitored more than 4,000 journals and selected monographs drawn from all areas of the natural and social sciences for input into several information services including the Science Citation Index (SCI) and the Journal Citation Reports (JCR). The only available large-scale citation indices are in fact compiled by ISI. These listings are dictionary controlled, however, only for journals and papers within those journals monitored by ISI. That is, computer dictionaries of journal name variants exist only for the ISI subset of the cited literature.

To assess the adequacy of the ISI coverage of research literature, we will use a comparison with an overall picture of the world research literature as provided by the acquisition tapes of the British National Lending Library. While the many abstracting services probably do make the most ambitious attempts of all bibliometric sources to provide complete coverage of subject literatures, they have not been merged into a single listing. Variations in abstracting style and content are inevitable, but they would not be critical for crude aggregations.[18] The ISI collection provides the only available bibliometric source for large-scale multi-disciplinary studies using citations. The main point of what follows is to indicate the nature and biases of that collection and to outline a methodology which overcomes those biases.

See References at end of text.

The extant literature of science is vast. While the degree of redundancy in science publishing is not known, it seems reasonable to assume that most current research finds its way into the serial literature, which, in general, includes periodicals, regular proceedings and reports and excludes irregular reports, monographs, textbooks and the rest of science publishing. Several estimates of the number of periodicals have been suggested, many of them based on the "World List of Scientific Periodicals".[19] This publication unfortunately is cumulative, including inactive titles, and uncritical in that it includes newsletters and bulletins.[20] With the acquisition of computerized tapes of literature titles by abstracting services and by some of the major science libraries in the world, it becomes possible to refine these lists, and to arrive at estimates of the currently available serial titles.

Refined library acquisition lists probably yield the most realistic estimates of those journals freely circulating in the world science community, and, for bibliometric studies, it is reasonable to ignore titles which are not widely available. For example, there appear to be many Chinese titles which have not been made available, and reports on research in classified areas which are often interrupted indefinitely.

The British National Lending Library attempts to acquire all available periodicals, i.e., publications "intended to be continued indefinitely", in science and technology. This includes natural, physical and engineering sciences, and encompasses psychology, medicine and agriculture. It excludes social sciences except from some borderline journals. Mark Carpenter and Francis Narin obtained computer tapes for the 1973 holdings of the British Library Lending Division (BLLD), which contained records of the 43,457 periodicals actually received, and of these, some 24,801 were thought to be actual research periodicals in the fields of science outlined above.[21] The number should not be directly compared with the earlier estimate by K.P. Barr, since he also examined records of periodicals on order as well as received. (Barr had found 22,619 research titles being received in 1965, with a further 3,616 on order. Experience at BLLD was that 60% of titles on order are eventually received.) Taking this into account, both estimates converge on a figure of 25,000 to 26,000 research periodicals for the mid-1960s. The high mortality rate among titles was seldom taken into account in the past, and it introduces an element of calm into the picture of the information explosion. While the list is changing in content, the doubling rate must now be set at about 60 years.[22]

Computerized library lists also include the addresses of the journal publishers and therefore, the geographical and disciplinary coverage of various collections can be compared. In fact, Carpenter and Narin have taken a preliminary step toward a comparison of this sort, which throws considerable light on the adequacy of coverage of the world's journal literature by ISI. They assigned the 24,801 research periodicals at BLLD to nine general subject fields. These periodicals were cross-referenced by country of publication to give a distribution of world research journals as shown on Table 1.1. A subjective allocation of titles was used for the limited purpose of description and comparison in the absence of any complete evaluation. This BLLD distribution is in fact the first available representation of world research journals with enough satisfactory detail concerning its construction to be considered reasonably accurate and complete.

Table 1.1 presents an interesting picture: over 80% of all journals come from North America and Europe and over 40% from English-language areas. The United States is predominant, contributing at least 20% of all journals in most areas. The skewness toward a mainstream in journal publication turns out to be even more pronounced in the publication of papers and citations. This journal distribution is not a suitable proxy indicator for research activity because of the international character of many journals, and one must remember that the strongest journals are very cosmopolitan in their authorship. However, it is clear that the communication infrastructure for world research is heavily dependent on the resources of the mature research communities of the United States and Western Europe. It would be interesting to identify the degree of this dependence, but the data (i.e., source of cited paper rather than source of journal) are not at hand for all countries.

Turning to the ISI journals included in the Science Citation Index (SCI) for 1975, and supplementing their subjective allocation procedure with a look at the range of references in the journals, Carpenter and Narin allocated 2,240 journals to the nine fields on Table 1.1. That is, they found that SCI was covering about 9% of the 24,801 BLLD journals in these fields. As we shall see, from our own more refined analysis of their relevance, the distribution of journals is highly skewed toward the great importance of a small percentage of them, and therefore 9% is probably more than would be needed overall to represent and analyse research areas in an objective way, with the important proviso that the higher quality journals were in fact being selected and that coverage was equitable. In fact, it is estimated that 85% of the 5 million references thus monitored in a year by ISI do go to the small percentage of journals covered in the SCI subset.

TABLE 1.1 Distribution of World Research Journals by Country and Field

Country	Clinical medicine	Biomedical research	Biology	Chemistry	Physics	Earth and space science	Psychol- ogy	Mathe- matics	Engineer- ing and technology	Total
	number									
United States	947	269	920	242	191	513	180	132	1,593	4,987
United Kingdom	333	171	602	173	145	229	60	77	1,346	3,136
U.S.S.R.	228	149	320	95	160	361	4	74	784	2,175
East and West Germany	399	94	278	84	89	214	46	77	702	1,983
Japan	352	82	292	53	52	130	13	36	511	1,521
France	296	65	210	27	44	158	27	41	410	1,278
Italy	296	41	138	25	37	79	7	26	184	833
Canada	69	14	167	8	9	139	9	13	159	587
Australia	47	17	158	12	14	80	3	7	183	521
India	88	24	112	12	7	37	11	19	154	464
Sweden	65	6	87	7	9	52	8	20	166	420
South Africa	18	1	58	4	4	37	4	9	54	189
New Zealand	15	1	52	1	1	26	-	4	38	138
Israel	6	-	13	4	-	10	-	5	19	57
Rest of East Europe	271	68	344	83	74	218	23	91	568	1,740
Rest of West Europe	631	135	589	97	107	400	38	138	854	2,989
Central and South America	294	47	267	24	18	141	9	37	147	984
Rest of Asia	90	18	120	8	6	79	2	20	103	446
Rest of Africa	40	4	97	2	3	59	1	18	24	248
Rest of Near East and North Africa	32	3	26	4	-	20	-	9	11	105
Total	4,517	1,209	4,850	965	970	2,982	445	853	8,010	24,801
Row percentage	18.2	4.9	19.6	3.9	3.9	12.0	1.8	3.4	32.3	100.0
	per cent									
United States	21.0	22.2	19.0	25.1	19.7	17.2	40.4	15.5	19.9	20.1
United Kingdom	7.4	14.1	12.4	17.9	14.9	7.7	13.5	9.0	16.8	12.6
U.S.S.R.	5.0	12.3	6.6	9.8	16.5	12.1	0.9	8.7	9.8	8.8
East and West Germany	8.8	7.8	5.7	8.7	9.2	7.2	10.3	9.0	8.8	8.0
Japan	7.8	6.8	6.0	5.5	5.4	4.4	2.9	4.2	6.4	6.1
France	6.6	5.4	4.3	2.8	4.5	5.3	6.1	4.8	5.1	5.2
Italy	6.6	3.4	2.8	2.6	3.8	2.6	1.6	3.0	2.3	3.4
Canada	1.5	1.2	3.4	0.8	0.9	4.7	2.0	1.5	2.0	2.4
Australia	1.0	1.4	3.3	1.2	1.4	2.7	0.7	0.8	2.3	2.1
India	1.9	2.0	2.3	1.2	0.7	1.2	2.5	2.2	1.9	1.9
Sweden	1.4	0.5	1.8	0.7	0.9	1.7	1.8	2.3	2.1	1.7
South Africa	0.4	0.1	1.2	0.4	0.4	1.2	0.9	1.1	0.7	0.8
New Zealand	0.3	0.1	1.1	0.1	0.1	0.9	-	0.5	0.5	0.6
Israel	0.1	-	0.3	0.4	-	0.3	-	0.6	0.2	0.2
Rest of East Europe	6.0	5.6	7.1	8.6	7.6	7.3	5.2	10.7	7.1	7.0
Rest of West Europe	14.0	11.2	12.1	10.1	11.0	13.4	8.5	16.2	10.7	12.1
Central and South America	6.5	3.9	5.5	2.5	1.9	4.7	2.0	4.3	1.8	4.0
Rest of Asia	2.0	1.5	2.5	0.8	0.6	2.6	0.4	2.3	1.3	1.8
Rest of Africa	0.9	0.3	2.0	0.2	0.3	2.0	0.2	2.1	0.3	1.0
Rest of Near East and North Africa	0.7	0.2	0.5	0.4	-	0.7	-	1.1	0.1	0.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: British Library Lending Division; M. Carpenter, F. Narin, "The Subject Composition of the World's Scientific Journals", *Scientometrics*, 2:1 (1980), p. 53; from the BLDD acquisition tapes for 1973.

While the overall extent of SCI coverage would seem to be adequate, the fact is that not all important journals have been selected, and the distribution among fields and among countries is very uneven, more than enough to seriously distort most international comparisons based on aggregate publication and citation counts. Table 1.2 provides a picture of this distribution comparing the SCI journals to those in the BLLD listing.

TABLE 1.2 Comparative Distribution of BLLD and SCI Journals(1)

	Clinical medicine		Biomedical research		Biology		Chemistry		Physics		Earth and space science		Psychology		Mathematics		Engineering and technology		Total	
	BLLD	SCI	BLLD	SCI	BLLD	SCI	BLLD	SCI	BLLD	SCI	BLLD	SCI	BLLD	SCI	BLLD	SCI	BLLD	SCI	BLLD	SCI
number																				
United States	947	234	269	99	920	112	242	56	191	40	513	44	180	56	132	31	1,593	198	4,987	870
United Kingdom	333	76	171	37	602	58	173	19	145	15	229	17	60	15	77	11	1,346	96	3,156	344
U.S.S.R.	228	10	149	11	320	3	95	17	160	14	361	4	4	1	74	2	784	17	2,175	79
East and West Germany	399	76	94	27	278	24	84	21	89	13	214	10	46	2	77	14	702	34	1,983	221
Japan	352	19	82	11	292	8	53	8	52	4	130	4	13	2	36	4	511	11	1,521	71
France	296	51	65	9	210	16	27	5	44	8	158	4	27	2	41	5	410	17	1,278	117
Other	1,962	177	379	80	2,228	73	291	60	289	29	1,377	31	115	13	416	20	2,664	55	9,721	538
Total	1,417	643	1,209	274	4,850	294	965	186	970	123	2,982	114	445	91	853	87	8,010	428	24,801	2,240
Row percentage	18.2	28.7	4.9	12.2	19.6	13.1	3.9	8.3	3.9	5.5	12.0	5.1	1.8	4.1	3.4	3.9	32.3	19.1	100.0	100.0
per cent																				
United States	21.0	36.4	22.2	36.1	19.0	38.1	25.1	30.1	19.7	32.5	17.2	38.6	40.4	61.5	15.5	35.2	19.9	46.3	20.1	38.8
United Kingdom	7.4	11.8	14.1	13.5	12.4	19.7	17.9	10.2	14.9	12.2	7.7	14.9	13.5	16.5	9.0	12.5	16.8	22.4	12.6	15.4
U.S.S.R.	5.0	1.6	12.3	4.0	6.6	1.0	9.8	9.1	16.5	11.4	12.1	3.5	0.9	1.1	8.7	2.3	9.8	4.0	8.8	3.5
East and West Germany	8.8	11.8	7.8	9.8	5.7	8.2	8.7	11.3	9.1	10.6	7.2	8.8	10.3	2.2	9.0	25.9	8.8	7.9	8.0	9.9
Japan	7.8	3.0	6.8	4.0	6.0	2.7	5.5	4.3	5.4	3.3	4.4	3.5	2.9	2.2	4.2	4.5	6.4	2.6	6.1	3.2
France	6.6	7.9	5.4	3.3	4.3	5.4	2.8	2.7	4.5	6.5	5.3	3.5	6.1	2.2	4.8	5.7	5.1	4.0	5.2	5.2
Other	43.3	27.5	31.3	29.2	45.9	24.8	30.2	32.2	29.8	23.6	46.2	27.2	25.8	14.3	48.8	22.7	33.3	12.9	39.2	24.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

71) BLLD Journals - 1973 data; SCI Journals - 1975 data.

Source: M. Carpenter, *International Science Indicators*, Computer Horizons, Inc. (Cherry Hill, New Jersey, 1979), Table I-9.

The results present us with some problems. Looking across the rows in the top of Table 1.2, i.e., the distribution of journals among fields, and for example, recalling a rather large number of engineering and technology journals in the BLLD data base (32%), we find here a much smaller share for the SCI (19%). On the other hand, the SCI coverage of biomedical research is notably larger than BLLD coverage (5% of BLLD, 12% of SCI), and this difference is repeated in clinical medicine (18% and 29%, respectively), chemistry (4% and 8%) and psychology (2% and 4%). Indeed this concentration of SCI journals in clinical medicine has been a bias since the late 1950s when the collection was initiated by Dr. Garfield to construct a genetic citation index.

A different kind of problem arises in mathematics where, while the presentation receives the same emphasis in the two data bases it is unevenly distributed among countries, as shown on the lower half of Table 1.2. Here the two major geographical biases in SCI are very evident: a serious under-representation of mathematics journals from the Soviet Union, which has 9% of BLLD mathematics and only 2% of SCI mathematics, and an over-representation of American journals in the area. For comparisons of international performance we note that language differences result in certain countries (particularly the U.S.S.R.) being infrequently cited by western authors but that authors in these countries, in most cases, reserve their best papers for those journals that are recognized internationally. A clustering analysis (the procedure developed for this study) will tend to identify and isolate these linguistically specialized journals, drawing into the mainstream only those which are cosmopolitan and actually used by the world community. This means then that while representation can be small, it must be reasonably accurate, and include all journals likely to have significant influence. Where the numbers are small, as in mathematics, missing a few key foreign-language journals, or a few key specialized journals will undermine the most ingenious procedures for obtaining comprehensive clusters of that field.

From our own point of view, we are concerned with an evaluation of Canadian research, in terms of its relevance in the world community. Therefore, the SCI overemphasis of English-language journals suggests that Canadian research may be over-represented in terms of crude publication and citation counts. Data for Canadian journals were not available for Table 1.2, but an impression can be formed of the situation for Canada from the following considerations.

In the BLD journal set for 1973, of the 24,801 publications, Canada published 587 journals, or 2.4% of the total and there is no reason to assume that this share would change between 1973 and 1977. But in an examination of 1977 ISI data, Eugene Garfield reported 46 Canadian journals, or only 1.8% of the SCI set for that year. This was despite the very strong overall representation of Canadian authored articles in the SCI set of 3.9%. One of the reasons for this is significant here: Canadian researchers work in an environment which is in many ways associated with the largest research community in the world. This has had profound implications throughout our research infrastructure, and particularly for the development of independent research institutions in this country, including professional associations and journals.

Without analysing this point in detail, the full extent of Canadian cosmopolitanism in research publishing was described empirically by Garfield.[23] He observed 14,238 source articles in the 1973 SCI journal set (including notes, editorials and reviews), which had indicated a Canadian location as their first listed address. As shown in Column 2 of Table 1.3, less than 30% of these were published in Canadian journals, while 50% were published in U.S. journals. He then looked at some of the citation patterns to these articles over the period 1973-76. The percentages of Canadian papers that were cited ranged from 38% for the few that appeared in Danish journals to 78% for those in West German journals, with 66% of those placed in Canadian journals. More important, of the Canadian papers that were cited, the citation rate was usually higher if they had been published abroad. As shown in Column 5, the rate was only 4.1 cites per cited Canadian paper published in Canada, but 6.5 for those published in the United States, and 7.2 in the Netherlands, where a number of major international publishing houses are established.

TABLE 1.3 Distribution of Canadian Authored Articles

Place of publication	Canadian papers(1)	Allocation to countries	Share cited 1973-76	Average citations to cited papers
	number	per cent	per cent	
United States	7,070	49.7	63.3	6.5
Canada	4,091	28.7	66.0	4.1
United Kingdom	1,439	10.1	69.0	5.2
Netherlands	679	4.8	74.7	7.2
Switzerland	235	1.6	71.1	4.7
West Germany	199	1.4	78.4	5.2
France	107	0.8	54.2	2.9
Denmark	106	0.7	37.7	6.1
Other	312	2.2	44.9	2.9
Total	14,238	100.0	64.9	5.5

(1) Includes articles, notes, editorials and reviews monitored in 1973.

Source: E. Garfield, *Current Contents*, 34, August 1979.

Noting the chosen language of the Canadian articles, Garfield also presented information which throws some additional light on the linguistic character of mainstream research, and the dilemma of francophone Canadian scientists. Less than 4% of Canadian articles were published in French, and of those only 39% were cited, a significantly lower rate than for English-language articles. In contrast, 64% of the English-language articles were cited. Thus, we observe that Canadian scientists as a whole publish heavily in the English-language mainstream of SCI journals, and their work tends to be more heavily cited when they do this.

See References at end of text.

Summary

Several points have been made about the citation data base accumulated at ISI. To summarize the implications of these observations for our study, the following points are noted:

- . An objective and thorough evaluation of the ISI data base, in terms of journal representativeness and importance has not yet been carried out. Though it is needed, the evaluation would require machine readable dictionaries to read the variants of cited journal names, where these journals are not covered by ISI. Since 1975, reasonably reliable computer dictionaries exist only for reading variant names of the ISI source journals.
- . The existing dictionaries permit the observation that the overall range of journals in the SCI data base (9% of the BLLD collection) is more than adequate, since 85% of the references monitored in a year are from SCI monitored journals.
- . A disciplinary and geographical distribution of SCI and BLLD journals demonstrates significant biases in the SCI representation toward biomedicine and toward U.S. representation, and to a lesser extent, toward coverage of English-language journals.
- . Canadian journals are not over-represented, but the journals in which Canadians publish are over-represented (the latter point does not hold for Canadian social science). As the basis for a study of Canadian research in the natural sciences, the range of representation appears adequate. The two biases in the distribution tend to cancel each other: since fields which are under-represented in SCI such as engineering, biology, earth and space sciences, and mathematics are, in fact, the fields in which there is an over-representation of U.S. and English-language coverage. The biases are more than enough to render simplistic bibliometric measures artifactual, but the methodology presented in Appendices II and III was designed to obviate an uneven disciplinary coverage.
- . Direct international comparisons of publication or citation counts would not be warranted, given these biases, except in cases where an effective control could be introduced and trends established (for example comparing incremental growth in country shares of papers in journal sets which are held constant and represent the same general areas of research).
- . Variations in the coverage of fields, variations in publication frequencies among research areas, and expected variations in the communication character of specialties at different stages of maturity, require that bibliometric indicators be developed only with respect to objective representations of those fields and research areas.

To conclude; these considerations together with other characteristics of the ISI data base (such as error levels and variants of authors and addresses), impose several constraints on procedures for the development of bibliometric indicators:

- . an evaluation and clustering of journals is required for the development of reasonable time series for national productivity in particular disciplines;
- . an initial (journal-driven) strategy, implementing some analysis of the ISI representation of research journals, followed by an evaluation of papers identified by a journal/volume/issue/page/year code, would seem to be called for in order to minimize the error levels in author and article names; and
- . additional analysis is required, based upon a methodology such as that outlined in the following section, in order to use the citation data in either a general or an evaluative way.

Computing Relevance Among Source Elements

In the previous sections we have seen where some of the difficulties lie in using the data available. Bibliometric records must be used with caution to measure achievement and peer recognition, particularly with respect to heterogeneous and large-scale collections of documents. Biases are present in both the data base and subject fields. This section first outlines a theoretical framework for evaluating the relationships (i.e., relative influence) among elements of an information source as a means of overcoming these difficulties and second, defines mathematically a measure of relative influence, termed "relevance", used to evaluate these relationships and thus the quality of contributions to research. Appendices II and III will provide more specific information about the procedures for implementing these ideas.

As discussed in "Limitations" bibliometric techniques have achieved some success in evaluating the quality of research at an institutional level within given fields of literature, and in developing maps of research specialties as perceived by the research community. But precision in both the evaluative task and in the structural analysis of source documents requires some stronger theoretical base, particularly for large, heterogeneous information sources. In mentioning the Lotka-Bradford-Zipf distributions, we have, in fact, already referred to the traditional theory of information science from which our theoretical base derives: science is an inquiring system.[24] Investigators, operating within the normative, cognitive and technical constraints of scholarly communities, inquire for information relevant to their dynamic state of learning. At the most primitive level, nature might be seen as the source of information. But investigators cannot confront nature directly nor at random; and, taking into account the cumulative characteristic of knowledge and the complex of symbolic systems and social relations which make this possible, the immediate source of information becomes the research community itself. We have noted above, that of all the information systems which may be active in a research community, special importance is attached to that particular, formal one which in fact provides a system for publishing and acknowledging knowledge claims.

Inquiry and learning are intellectually costly processes. The limitations of short-term memory and human information processing within social groups impose serious constraints on researchers. They must accept a variety of classification and coding strategies, for example, selecting from a small core of favoured source elements (the "Matthew effect" of elitism in science which turns up in the Bradford-Zipf distributions), rather than inquiring at random over the whole source. A source of scientific information, such as the community of researchers itself, turns out to be functionally divided into research areas, and the relative importance of documents and individuals within these areas in turn is radically skewed. That is, under given conditions of use, an information source naturally partitions into classes and orders itself with respect to the importance of class elements.

Inquiry and learning are also time-dependent, and thus what will be pertinent to a user of an information source is very much a function of what the investigator already knows, and hence, where he or she is presently inquiring for pertinent information. Accordingly, users trace out quite specific directional pathways among the elements of an information source, ordering it and pointing to its most important elements. By formalizing these relations mathematically, we can find the most important source elements, and classify the source. Depending upon the level of specificity required, source elements can be identified as either papers, or authors, journals or institutions. Our implementation involves cited papers and cited journals.

Given a file of citing papers for each cited paper, we can derive two probability measures: (1) the marginal propensity of authors to inquire from one paper to another, represented by W. Goffman's transition probability,[25] and (2) the relative frequency with which each of these ordered pairs of cited papers is chosen from among all ordered pairs of cited papers in the citation index. These two measures are the basis of the term we call "relevance".

The transition probability measures the conditional probability that given an author makes reference to any given paper, he will, in the same article, make reference to any other specific paper in the whole source of cited papers. This means the two papers are associated together in terms of intellectual distance (i.e., a relation of influence exists between the two cited papers). Moreover, after a few months' worth of accumulated citations, a direction will have been established showing the greater probability of citing investigators to move toward particular papers. While the transition probability reflects the relation of influence between papers by measuring the propensity of investigators to inquire across any given linkage, it suppresses the relative importance of the various linkages (i.e., pairs of cited papers). Sensitivity to this factor is introduced by measuring, in a comparative way, the contribution of each linkage to all possible linkages within the citation index.

Relevance therefore defines a set of mathematical relations among papers, the properties of which are most important, and permit us to order these pairs into chains; partition them into exclusive classes; obtain a measure of the relevance of any cited paper to all other cited papers (the sum of the relevance of each of the linkages to a paper from all other papers);[26] and obtain a measure of the relevance of any class of cited papers (the sum of the relevance of all papers in that class).

The transition probability helps to overcome several of the biasing factors mentioned previously. For instance, in the case of self and prestige citing, repeated self-cites would have no biasing effect on this measure, and the directionality distils from prestige citing a correct measure of the influence of Einstein upon oneself, and not the other way around. Similarly, for a data base that over-represents some part of a system of papers, transition probabilities reflect the actual use of what is there, the way that inquiring users make use of actual and always incomplete collections. Moreover, the intrinsic variations in citation rates from one research area to another do not bias this measure; i.e., other things being equal, a directed path of a mathematics cluster of papers will compute in a similar way for one in chemistry, though the production or citation rate may differ by an order of magnitude.

The transition probability, however, has two major defects. Firstly, it was designed for small homogeneous data bases accessed by a given single set of users. This means in defining clusters of related papers a single threshold could be set on the marginal relevance required by a linkage to augment the cluster. Secondly, within a cluster of papers, it submerges the relative importance of the various linkages. That is, in the same research specialty, a transition probability computed from five co-citations on an initial citation file of 30 will be the same as a much less travelled and correspondingly less important (peripheral) linkage of 1 in 6. Thus, to overcome this latter problem, the relative importance of each linkage of cited papers was introduced. With respect to the other problem of variations in a large data base, an (incremental) approach was devised that allows for a computer algorithm to select a threshold of marginal relevance to be established which is appropriate for each cluster, or research area.

To summarize, in practice a large-scale application will encounter many imperfectly monitored specialties, linguistically isolated journals, and emergent specialties. The user population, and indeed the data base, must be considered heterogeneous. Therefore, the marginal relevance of linkages in a chain of cited source elements requires a threshold condition that is sensitive to local conditions of inquiry (Appendix III). Given an algorithm which meets this condition, we can make use of the analytical power of Goffman's approach for sources that are very large and heterogeneous. The strategy consists of making use of the mathematical properties of a directed graph of relevance relations on the source. Technically, a chain of relevant linkages imposes a transitive ordering relation on the source, while elements which are interconnected by such chains (defining a symmetric relation) may be partitioned into mutually exclusive classes. An algorithm was devised (Appendix III) which computes the relevance of source elements and which grows clusters of elements by inputting marginal relevance incrementally, thus classifying source elements in terms of those which are interconnected by networks of relevance relations.

Relevance relations reflect a collective evaluation of influence among papers in a scientific field. Perfunctory, prestige and self citing behaviours notwithstanding, the citation indicates an acknowledgement of knowledge claims. However, because of variations in citing behaviour and because of the biases which result from the error types noted earlier, the citation cannot be quantified as a measure of information flow. Rather, it can be used to derive two probability measures which are not sensitive to these sources of error and no amount of self, prestige or perfunctory citing, nor bias in monitoring the source, will alter the relations of influence which are thus collectively imposed by the research community itself. By formalizing these relations, we can find the most important source elements and discover a working classification of the source.

Chapter 2

CLASSIFYING THE SYSTEM OF JOURNALS

Methodology

The relevance theory was applied to both the journals and the papers within the journals of the ISI collection. A computer algorithm was devised and used to first evaluate the relevance of all ordered pairs of the 4,000 ISI journals; and then to evaluate the relevance on all ordered pairs of papers published in those journals in the three selected years 1974, 1975 and 1976, based on their citation files for 1978. Separate procedures were used for the journals and papers since computational efficiency, critical to the problem of clustering algorithms (see Appendix III), is quite different in each case.

In practical terms there is no limit to the possible size of a system of informational elements whose relevance relations are to be computed (essentially it can be resolved into a computational and sorting problem); but on the other hand, the clustering part of the evaluation is more severely constrained, and until a graph theoretic approach was found, they had been limited to very small information sources of about 100 elements or less.[27] The result of this was an excessive level of subjective interference and selection.

The algorithm developed for this study is optimal in terms of efficiency and, a standard mainframe with current enhancements can handle about 20,000 elements (a matrix of 4×10^8 cells), which is large relative to the world's journals, but still small in relation to all cited papers in a period of three years. Thus an initial journal analysis was required to classify groups of related journals which would then form the basis for classifying the papers that turn out to be relevant in a separate evaluation of cited papers. The clustering part of the algorithm operates incrementally, reading in ordered pairs of source elements, from the most relevant linkage to the least relevant; and then forming clusters of interconnected elements in a systematic fashion. In the case of the journal analysis, when a marginal linkage failed to augment the accumulated relevance of a class of journals by more than 0.5%, the class was considered sufficiently complete or saturated. Such a class or interconnected network of source elements is called a **research front**, and in this case, a research front of journals.

In the early 1970s, ISI devised a computer dictionary to read the variant names of those cited and citing journals monitored at the Institute. On the basis of this dictionary, a journal-to-journal citation index called the **Journal Citation Reports**, is produced. At the journal level of aggregation, a citation index becomes rather a blunt instrument of analysis, particularly with respect to multidisciplinary journals. In fact, the analysis could be made much more specific but only the JCR was available for the pilot project.

An analysis of the tapes of the 1978 JCR was carried out; relevance values were computed for some 4.6 million ordered pairs of cited journals; they were rank ordered and then read into the clustering algorithm. The ordering displays a characteristically skewed form of a log-normal or Bradford-Zipf curve. The first research front saturated when the top 400 relevance pairs had been read in. Indeed, what one might consider to be the core of the system contains only 40,000 of a total 4.6 million ordered pairs or linkages of cited journals with non-zero relevance in the collection, but this small network accounts for about half of the system's relevance. After the first 56 research fronts were identified (i.e., had saturated), the remaining journals were increasingly peripheral to the system frequently consisting of unit classes with little influence on the rest. Thus, if we include only those fronts which exert some influence on at least one saturated front (i.e., only those journals found to be at least minimally influential), 85 fronts in the system were identified. They contain just 1,468 of the original 4,000 journals, but they account for 96% of the total relevance of all linkages in the system.

The clustering algorithm is iterative, and can be re-run to find super-classes (classes of fronts). A class or group of related research fronts is called a **research field**. Thirty-six such fields were identified in the journal system representing rather general or broader areas of science. The journals classified in this way are listed alphabetically in Appendix VI. A journal class was

See References at end of text.

called a research front following Price's terminology, and was denoted by a field: front sequence, as in R.F.i:j, where i = field and j = front (see Reference 17). Appendix IV provides a concordance of fronts into fields along with the results of the journal classification exercise, listing each research front as it was saturated in the analysis. The names suggested for each front are for the convenience of the reader and result from a scan of journal titles in each front.

The Journal Collection

The work on the system of journals is of interest because it is really the first time a structural analysis of any sort has been carried out on a set of documents representing, however, imperfectly, "the whole of science". The analysis of the citation data for 1977 from the 1978 JCR yields the following results.

The top-ranking journals were in the following order: *Nature*, *Science*, *Journal of Biological Chemistry*, *N.A.S. Proceedings*, *Biochimica et Biophysica Acta*, *Lancet*, *New England Journal of Medicine*, *Journal of Clinical Investigation*, *Annals of New York Academy of Science*, and tenth, *Journal of the American Chemical Society*. *Physical Review Letters* and *Royal Society of London, Proceedings, Series A* also appeared very high in the ranking, numbers 29 and 38 respectively; and the top Canadian journal was *Canadian Journal of Chemistry*, journal number 54.

Eighty-five clusters of journals (i.e., research fronts) that had at least a minimal degree of relevance/influence on the collection were identified. Fifty per cent of the total journal collection's relevance is contained in the first 22 research fronts identified (96% is contained in the 85 fronts).

These 85 fronts contain 1,468 "relevant" journals of the original 4,000 considered and are identified in the order of their influence on the system. The most influential research front, Core Biochemistry (R.F.1:1), as shown in Chart A, is a multi-disciplinary cluster of 12 journals related through their orientation to biochemistry. These journals contain papers in areas outside of biochemistry but it is their central influence in biochemistry which predominates.

Chart A. Journals Comprising the Research Front of Core Biochemistry

R.F.1:1:

1. NATURE, 1869, London, England, 14.4%, E.
2. SCIENCE, 1883, Washington, D.C., 13.0%, E.
3. JOURNAL OF BIOLOGICAL CHEMISTRY, 1905, Bethesda, Md., U.S.A., 12.0%, E.
4. NATIONAL ACADEMY OF SCIENCES, 1915, Washington, D.C., 10.6%, E.
5. BIOCHIMICA ET BIOPHYSICA ACTA, 1947, Amsterdam, Netherlands, 10.3%, E.
6. BIOCHEMICAL JOURNAL, 1906, Colchester, England, 8.2%, E.
7. BIOCHEMICAL AND BIOPHYSICAL RESEARCH COMMUNICATIONS, 1959, New York, U.S.A., 7.0%, E.
8. BIOCHEMISTRY (U.S.), 1962, Washington, D.C., 6.5%, E.
9. ARCHIVES OF BIOCHEMISTRY AND BIOPHYSICS, 1942, New York, U.S.A., 5.6%, E.
10. EUROPEAN JOURNAL OF BIOCHEMISTRY, 1967, Berlin, West Germany, 4.2%, E, F, G.
11. JOURNAL OF MOLECULAR BIOLOGY, 1959, London, England and New York, U.S.A., 4.1%, E, F, G.
12. FEBS LETTERS, 1968, Amsterdam, Netherlands, 4.0%, E, F, G.

Within each research front, the journals are listed in order of their total relevance in the entire system. Thus, reading under R.F.1:1, we find the journal **Nature**, founded in 1869, published in London, England supplying 14.4% of the relevance of all journals in the front and published in English. Note that the five strongest journals in the whole system of journals form a "clique" at the centre of R.F.1:1. The influence of the 12 journals in R.F.1:1 extends throughout the system. On a directed graph representation of interfront relevance relations (a relevance digraph), this fact is evident in the large numbers of relevance pathways from all fields into the central core of the graph.

This core group of fronts contains, in addition to R.F.1:1, the research fronts of Core Medicine (R.F.1:2), Core Chemistry (R.F.4:3), and Core Physics (R.F.3:4). Their influence extends throughout the entire journal collection and together they evidently represent the "central core of influence" of the whole collection.

After this central core of research fronts was identified (i.e., sequentially saturated by the algorithm) the groups which follow first tend to represent the core areas in more generalized and then more specialized or linguistically isolated forms. Also, many of the less influential fronts frequently consist of unit classes with little or no influence on the rest of the collection. These tend to represent imperfectly monitored research specialties, newly emergent specialties or linguistically isolated journals and are considered peripheral to the mainstream research fronts which are internationally representative or cosmopolitan.

The field which links the main clinical and biomedical research fronts together contains six closely related research fronts: Core Biochemistry (R.F.1:1), Core Medicine (R.F.1:2), Pharmacology and Clinical Chemistry (R.F.1:5), Cell Research (R.F.1:6), Gastroenterology, Surgery (R.F.1:7) and Immunology and Pediatrics (R.F.1:8).

Core Chemistry (R.F.4:3), which saturated as the third front, is very strongly intra-connected, and therefore integrated, and formed a field by itself. It is, of course, central to the rest of the physical sciences. The front is dominated by the **Journal of the American Chemical Society** and **Journal of Chemical Physics**, but the **Canadian Journal of Chemistry** is actually the sixth strongest journal in the world mainstream of chemistry publications.

Summary

The collection would appear to be highly integrated with respect to all of science and technology as evidenced by the interclass linkages; this contradicts the prevailing view that these are separate knowledge systems. For example, though we have adopted the journal citation tool as an obviously blunt and preliminary instrument, our subsequent evaluation of the influence of papers refines, but nowhere contradicts, the general observation that the entire system is highly integrated. The research journals of science and technology define a system of knowledge, and that system appears not to have a simple lattice or tree structure, built up from the most basic research areas to the most applied. Instead, system structure spirals outward from a central core, reproducing the mainstream classes in more specialized or linguistically isolated and peripheral forms.

For several reasons, the journal evaluation results should be considerably more reliable than impact factors.[28] However, our purpose here is not to refine a classificatory system for science, but to implement a methodology which overcomes the general problems inherent in the development of bibliometric indicators and the limitations of the ISI data base. Thus, the minimal requirement of the journal analysis is to partition and order the system of journals into fronts in a non-subjective fashion, so that the subsequent analysis of papers and derived indicators can be made meaningful.

Preliminary Descriptive Indicators

As noted, the central purpose of the pilot study was to develop a method to analyse papers using the relevance measure as the chief "evaluative" indicator. However, given a classification of the system of journals into comparable homogeneous groups, as outlined in the previous section, it is easy to develop a group of descriptive indicators based upon a time series of papers and co-authorship counts. The actual number of publications for any country would not be meaningful by itself, but useful indicators can be developed: for example, by controlling the research fronts of journals over time, one can reasonably look at incremental changes in national shares, or, where a country is strongly represented in a research front, relevant trends in the productivity of particular institutions may become apparent.

As previously noted, while Canadian journals are not over-represented in the data base, the journals in which Canadians publish are undoubtedly over-represented in a global context. This is a good thing for the purpose of our analysis, but of course it requires caution in interpreting productivity levels internationally.

International Shares of the World's Scientific Papers

Controlling for the introduction of new journals from 1974 to 1978 (and for increases in journal size by taking share values), Canada's share of the world's scientific papers fell slightly from 4.6% to 4.5%, as did shares for the United States (45.3% to 43.5%), and Britain (9.8% to 9.4%). Table 2.1 presents the distribution and change in world share of papers by journal front for Canada, the United States and England, for those fronts in which the three countries at least minimally participated.

Measuring national changes in production levels by the percentage change of 1978 production over 1974 production, and taking only the 32 most influential journal fronts in the system, we may note that the number of Canadian papers increased by at least 5% in 14 research fronts, declined by at least 5% in 11 and remained within that range for seven others. This pattern was similar to that for the United States and England, with 15 and 14 significant gains respectively. (Since the numbers reflect national coverage at ISI, international data is reserved for the discussion of relevance below and national shares are summarized here.) It is unlike the pattern for Japan, Italy, West Germany and France, where gains showed up in 28, 27, 24 and 22 research fronts respectively (data not provided). This pattern in Western Europe is inconsistent with the argument that mature research communities like the United States and Britain are merely maintaining their world share. In fact, the data would seem to indicate an overall process of redistribution of research with gradually more activities being taken up outside the English-language mainstream.

The numbers of papers from developing countries is still too small in particular fronts to test the notion of a redistribution statistically, but we can measure the overall dispersion of activity among countries by means of standardized gini and entropy measures. These measures were computed for 23 fields of journals involving at least 20 countries, and in all cases but one, the dispersion of activity increased among countries from 1974 to 1978 (again, we are summarizing a large volume of data which cannot practically be provided). The one exception was field 1 (including R.F.1:1, 1:2, 1:5, 1:6, 1:7 and 1:8, representing the most influential research fronts in biochemistry and medicine). The number of countries participating in these fronts increased slightly from 113 to 117 in the period; and the concentration of activity among them, when standardized for comparison, also increased. But in all other cases, the opposite tendency was evident, indicating a slow process of redistribution of activity in the physical sciences away from the most concentrated regions of the United States and Britain. For the most part, it means a greater participation rate in Western Europe, Australia, Israel, South Africa, and to a lesser extent, some East European countries. There is as yet little sign of the long-anticipated redistribution of particular research activities to Third World countries.

While these shifts in influence are undoubtedly a good sign for the health of the world research community, research in Canada, unlike that in the United States and Britain, is not yet fully developed in all sectors and should still be expanding in terms of activity levels.

Table 2.1 provides some details of Canadian activity, showing where increases in world share have taken place. As discussed earlier and evident from Appendix IV, many of the research fronts are very small or isolated linguistically and thus, relatively unimportant from our point of view. The range, as for the United States, is very broad, indicating that we are not a specialized research power. Of the 80 journal fronts in Table 2.1 Canada participated in 77 of them in 1978, publishing 100 or more papers in 41 of them. We increased in world share between 1974 and 1978 for 22 of the fronts and decreased for 19. In only three of the positive increments did we increase world share by more than 1%: in Ecology (R.F.2:21, with journals in ecology, marine biology, entomology); in Clinical Pharmacology, Geriatrics (R.F.2:43) and in Animal Biology (R.F.10:38 with journals in animal behaviour, zoology, applied ecology). These all represent areas dominated by governmental and regulatory science. It is the kind of science normally associated with an early stage in the evolution of a country's research infrastructure: a period often rather unkindly but accurately referred to as its colonial period.

Table 2.1 also shows that the Canadian research community experienced six significant declines in world share. These tended not to be in areas of colonial or regulatory science and the stewardship of resources, but unfortunately involve more fundamental areas. For example, our share of papers in Microbiology and Macromolecular Science (R.F.2:15) declined by two percentage points; this is an important group of journals in microbiology, genetics and polymer science. Another significant decline in world share was in Solid State Physics (R.F.3:10) including journals in micro-electronics and surface sciences. This represents the knowledge base for our developing micro-electronics industry, and

TABLE 2.1 World Shares of Papers by Journal Front for Selected Countries(1)

Canada				United States				England				
	1974	Per cent world share	1978	Per cent world share	1974	Per cent world share	1978	Per cent world share	1974	Per cent world share	1978	Per cent world share
R.F.												
1: 1	633	3.56	600	3.14	10,133	56.98	10,618	55.49	1,742	9.78	1,652	8.63
2	697	3.01	845	3.12	15,026	64.83	16,939	62.61	3,376	14.56	4,067	15.03
5	398	4.19	436	4.16	4,592	48.32	5,131	48.90	1,113	11.71	1,066	10.16
6	353	3.90	421	3.97	5,469	60.45	6,370	60.00	561	6.20	636	5.99
7	255	3.72	254	3.26	5,112	74.54	5,759	73.95	569	8.30	625	8.03
8	1,057	7.63	1,208	7.83	7,750	55.95	9,169	59.45	1,561	11.27	1,090	7.07
2:12	497	8.40	375	9.32	3,848	65.00	1,959	48.67	453	7.65	384	9.54
15	314	8.21	282	6.09	1,308	36.08	1,579	34.13	329	8.60	362	7.82
19	159	1.41	312	2.27	4,335	38.45	5,916	43.02	818	7.26	901	6.55
21	634	17.43	769	21.77	2,413	66.33	2,208	62.50	138	3.79	147	4.16
24	157	4.39	240	5.01	1,356	37.91	2,011	41.98	280	7.83	367	7.66
26	139	4.27	115	5.15	2,484	76.22	1,529	68.47	305	9.36	289	12.99
27	110	2.54	191	3.50	1,864	43.02	2,397	43.92	479	11.05	473	8.67
32	126	4.57	182	4.85	1,003	36.38	1,776	47.35	654	23.71	683	18.21
36	193	2.12	199	2.00	2,564	28.21	3,184	32.01	323	3.55	461	4.64
39	113	3.43	124	3.72	1,073	32.61	976	29.34	149	4.53	175	5.26
40	26	4.51	2	2.17	519	89.95	82	89.13	10	1.73	1	1.09
43	210	5.72	348	8.12	1,396	38.01	1,370	31.96	406	11.05	635	14.81
44	97	11.01	92	6.97	447	50.74	478	36.24	113	12.83	267	20.24
46	112	2.95	117	2.09	985	25.98	1,544	27.96	217	5.72	646	11.55
56	88	2.24	132	2.75	1,112	28.26	1,486	30.93	111	2.82	248	5.18
3: 4	480	2.95	530	3.13	8,072	49.66	7,474	44.09	1,067	6.56	889	5.24
9	348	3.92	318	3.35	1,619	18.25	1,610	16.95	1,496	16.87	1,192	12.55
10	719	6.61	578	4.84	3,543	32.57	3,877	32.47	748	6.88	690	5.78
14	519	6.45	617	6.88	4,199	52.17	4,484	50.03	403	5.01	421	4.70
4: 3	1,113	7.37	1,083	6.90	7,078	46.90	6,799	43.31	788	5.22	757	4.82
5:11	362	12.02	317	9.05	1,004	33.33	1,025	29.25	338	11.22	423	12.07
20	156	2.32	162	2.79	1,499	22.31	1,204	20.76	454	6.76	444	7.65
25	61	0.57	50	0.50	338	3.16	403	4.06	141	1.32	102	1.03
29	306	8.02	323	8.75	2,394	62.75	1,976	53.52	267	7.00	295	7.99
6:17	224	9.02	124	6.79	1,684	67.82	1,111	60.88	51	2.05	37	2.03
30	257	4.14	212	3.49	3,130	50.45	2,622	43.22	507	8.17	467	7.70
57	39	3.75	47	4.58	719	69.13	654	63.74	60	5.77	55	5.36
7:34	205	4.03	178	3.15	1,397	27.45	1,427	25.29	227	4.46	197	3.49
41	81	3.43	127	3.65	934	39.58	1,004	28.85	197	8.35	294	8.45
51	40	1.49	47	1.51	393	14.64	454	14.57	98	3.65	103	3.30
53	44	1.96	65	2.29	602	26.80	793	27.97	95	4.23	145	5.11
79	42	2.78	22	1.34	119	7.87	65	3.96	51	3.37	56	3.41
8:13	535	7.02	543	7.55	4,711	61.80	4,023	55.93	417	5.47	478	6.65
9:23	177	2.48	131	1.84	1,375	19.27	1,411	19.78	957	13.41	732	10.26
31	49	3.99	129	4.87	614	50.05	1,647	62.17	106	8.64	149	5.62
42	154	5.00	195	4.74	1,675	54.35	2,238	54.44	137	4.45	152	3.70
48	36	3.99	54	4.62	611	67.66	787	67.38	51	5.65	69	5.91
61	61	6.59	87	8.07	347	37.51	438	40.63	93	10.05	121	11.22
10:28	2	2.70	8	7.21	51	68.92	62	55.86	5	6.76	7	6.31
38	120	5.63	187	7.14	1,220	57.20	1,493	56.98	240	11.25	270	10.31
45	137	7.97	103	7.84	1,238	72.06	913	69.54	177	10.30	153	11.65
49	36	2.37	50	3.02	300	19.76	295	17.82	44	2.90	74	4.47
50	396	6.78	399	6.75	1,940	33.22	1,783	30.17	392	6.71	276	4.67
54	35	2.80	61	3.25	590	47.16	595	31.70	66	5.28	141	7.51
58	8	5.56	6	5.41	122	84.72	87	78.38	3	2.08	5	4.50
61	32	5.55	27	3.59	315	54.59	338	44.89	64	11.09	57	7.57
63	5	2.07	33	5.19	179	74.27	503	79.09	20	8.30	29	4.56
11:18	147	4.62	198	5.00	1,880	59.06	2,319	58.50	330	10.37	311	7.85
13:22	23	1.02	35	1.56	1,134	50.20	1,020	45.52	157	6.95	212	9.46
37	43	3.52	39	2.30	839	68.71	1,081	63.78	12	0.98	73	4.31
14:47	326	7.34	263	6.16	2,449	55.15	2,026	47.43	412	9.28	438	10.25
52	-	-	-	-	-	-	-	-	-	-	-	-
55	4	2.47	16	8.79	132	81.48	122	67.03	5	3.09	3	1.65
82	27	9.06	25	6.10	139	46.64	171	41.71	30	10.07	39	9.51
15:35	46	2.11	63	2.73	1,328	61.02	1,396	60.41	108	9.56	213	9.22
17:59	42	9.90	46	10.13	303	71.46	271	59.69	15	3.54	22	4.85
18:66	3	0.24	3	0.17	18	1.47	22	1.24	2	0.16	4	0.23
19:85	9	3.16	3	1.44	117	41.05	71	34.13	53	18.60	35	17.30
20:65	13	3.41	16	6.15	285	74.80	184	70.77	50	13.12	28	10.77
21:67	5	2.72	-	-	2	1.09	1	0.53	1	0.54	1	0.53
22:68	129	16.69	111	11.62	300	38.81	408	42.72	43	5.56	46	4.82
23:72	11	0.55	72	2.01	257	12.90	791	22.12	13	0.65	151	4.22
24:73	15	6.20	22	10.23	188	77.69	140	65.11	10	4.13	25	11.63
25:60	5	3.55	20	11.63	73	51.77	94	54.65	17	12.06	16	9.30
26:75	-	-	6	3.90	-	-	-	-	-	-	1	0.65
27:62	2	2.02	2	2.56	13	13.13	7	8.97	16	16.16	18	23.68
28:64	3	2.73	3	1.90	16	14.55	22	13.92	44	40.00	80	50.63
29:69	16	17.39	17	15.04	49	53.26	65	57.52	1	1.09	6	5.31
30:70	2	2.00	9	4.13	-	-	17	7.80	-	-	8	3.67
31:71	-	-	16	22.86	-	-	37	52.86	-	-	4	5.71
32:74	14	2.38	34	7.42	544	92.36	403	87.99	-	-	-	-
33:76	3	2.46	3	2.01	117	95.90	142	95.30	-	-	-	-
35:80	2	4.00	-	-	3	6.00	7	14.58	16	32.00	16	33.33
36:84	-	-	9	4.21	-	-	59	27.57	-	-	23	10.75

(1) Represents a count of country addresses for all papers monitored in 1974 and 1978, respectively.

is an area, as we shall presently see, in which Canadians contribute a high proportion of significant papers. A decline in activity here, as in microbiology, could turn out to be costly in several respects. The decline in Plant Biology (R.F.5:11), covering botany and cell physiology, was from an overly high level of activity in an area of science that, while important to agriculture, reflects the scientific preoccupations of our colonial past. With reference to Main Mathematics (R.F.6:17), we have noted that our participation level may be artificially high because of seriously incomplete coverage. Nevertheless, a loss of more than two points in world paper shares is not at all a good sign, and again, this occurs here in the face of a disproportionately high Canadian share of the top papers (12%, see below). Another decrease in world share is in Applied Mathematics and Computer Science (R.F.14:47), involving 37 important journals in computer science, automation and control theory, numerical analysis, etc. Finally the sixth decline was also in an area of economic importance; this time involving government science to a larger degree and the result of a drop from a high level of activity. This area, Secondary Veterinary Science (R.F.22:68) is represented by a small group of eight journals in animal research and veterinary medicine. Recent institutional development in this area by Agriculture Canada's Research Division may by now have reversed this trend.

Table 2.2 shows some of the trends in levels of research activity for countries with at least 1% of papers in the three most strongly connected fronts (Core Biochemistry R.F.1:1, Core Medicine R.F.1:2, and Core Chemistry R.F.4:3). U.S. publications increased from 10,133 to 10,618 papers from 1974 to 1978 (see Table 2.1) in the 12 key journals of Core Biochemistry, representing a drop in world share from 57.0% in 1974 to 55.5% in 1978. The absolute increase results from increases in the publication of papers by the journals themselves - this is normal for most journal classes. In Core Biochemistry the number of Canadian publications fell by 5.2% from 1974 resulting in a slight drop in our share of world activity. We maintained a share of about the same magnitude in the main medical group, although, in order to do this, the actual number of Canadian papers increased from 697 to 845, in line with a corresponding increase in the papers published in those journals. In the Core Chemistry research front, the Canadian volume dropped by 3% from 1,116 to 1,083 papers and our share of all papers in the front dropped slightly to about 7%. The large and expanding volume of activity in Japan and West Germany in this area is notable.[29]

International Co-authorship Linkages

Co-authorship among countries is another useful descriptive indicator which is readily available for controlled journal fronts. This analysis is based on co-authorships identified as pairs of addresses.

Canada had 11,555 linkages of this kind in the address records of the 1,468 relevant journals for 1978; 8,868 of these were combinations within Canada. That is to say, 23% of the co-authorships that involved at least one Canadian address, also involved a foreign address. In terms of this measure, Canadian research would seem to be slightly more cosmopolitan in the period from 1974 to 1978, since 22% of Canadian co-authorships involved a foreign author in the earlier year.

It is often remarked that when a Canadian researcher chooses professional societies, schools for graduate training, recruiting and collaboration, or journals in which to publish, the United States will usually turn out to be the first choice. However, there are signs that Canadian researchers are increasing their involvement with other countries. Table 2.3 provides an indication of our international involvement through co-authored articles.

While the distribution of Canadian co-authorship linkages among countries remained about the same over the period (the 13 countries listed accounted for 92% of all our international linkages in both 1974 and 1978), within that distribution, there was a diminishing emphasis on the United States and considerably more activity with researchers from France, Australia, Japan, Sweden, Italy and Israel. Links to East European countries are still sporadic, 12 with Poland for example, and eight with Hungary; and similarly for Third World countries, with the exception of India, where some traditional ties have survived.

Pursuing this indicator into more controlled conditions, we can briefly observe the international linkages in Core Biochemistry (R.F.1:1), all of which are well-known international journals involving a number of specialties. The international co-authorship matrix for R.F.1:1 (not provided) is again a symmetric matrix, each column representing the frequencies of co-authorship. Without reproducing this very large matrix, we note that a well-known centre-periphery phenomenon is evident therein, with access to and control of the main international journals obviously a key ingredient of centre-status. The column for the United States indicates a cosmopolitan range of interaction with 51 other countries for 1974, with considerable depth in a number of the entries. Twenty-five per cent of these linkages were with British addresses, 11.0% Canadian, 8.0% West German, 7.0% Italian, 5.5% Dutch, 5.2% French, 4.6% Swedish, 4.4% Japanese and 4.3% Israeli. Major East European linkages included 14 (or 1.3%) with

TABLE 2.2 Changes in World Shares of Papers for Three Journal Fronts

Country	1974	1978
	per cent	
Core biochemistry (R.F.1:1)		
United States	57.0	55.5
England	9.8	8.6
West Germany	3.9	4.4
France	4.0	4.5
Japan	3.4	4.3
Canada	3.6	3.1
Sweden	2.0	1.8
Netherlands	1.4	2.1
Israel	1.7	1.7
Italy	1.7	1.7
Switzerland	1.2	1.6
Australia	1.6	1.5
Scotland	1.2	1.0
Belgium	0.8	1.1
Core medicine (R.F.1:2)		
United States	64.8	62.6
England	14.6	15.0
Canada	3.0	3.1
Scotland	2.4	2.2
Japan	1.2	1.6
France	1.4	1.8
Sweden	1.4	1.6
Australia	1.3	1.1
West Germany	0.9	1.0
Core chemistry (R.F.4:3)		
United States	46.9	43.3
Japan	11.0	11.9
West Germany	8.0	11.0
Canada	7.4	6.9
France	4.8	5.3
Switzerland	2.5	2.3
England	5.2	4.8
Italy	2.5	2.6
Israel	1.4	1.0
Netherlands	1.3	1.4

TABLE 2.3 International Co-authorship Linkages with Canada

Country	1974	1978
	per cent	
United States	65.0	59.8
England	8.8	9.9
France	3.7	6.5
Australia	1.8	2.9
West Germany	3.4	2.3
Japan	1.3	2.0
Sweden	1.0	1.9
Italy	0.9	1.6
Israel	0.7	1.3
Netherlands	1.2	1.1
Switzerland	1.1	1.1
Scotland	1.4	0.9
India	1.1	0.9
44 other	8.6	8.2
Total	100.0	100.0
Co-authorships with foreign countries	22	23
Co-authorships within Canada	78	77

Poland and only 11 or 1% with the U.S.S.R. (For all research fronts for 1978, U.S. links with East Europe were infrequent: 96 with Poland, 61 with Hungary, compared with 1,606 with Canada, 1,377 with England, and 998 with West Germany.)

The profile of Canadian international linkages for R.F.1:1 is somewhat more concentrated: 19 other countries, compared with 42 other countries for the U.S. (1978). The striking feature of this profile is the concentration of 65% of the linkages with the U.S. The rest of the profile seems somewhat cosmopolitan and balanced: 11% with England, and 4% each with Italy and the Netherlands, and only 2% with France, the same as for Denmark and West Germany. Language would thus seem to be a determinant of effective collaboration as would geographic location. There are mixed signs for improvement in the situation: the range had increased since 1974 from 13 to 19 other countries, but our pre-occupation with U.S. linkages actually increased by two points, and a strong set of linkages with West Germany (10%) virtually disappeared over the period.

A possible explanation for this is that while the National Research Council (NRC) slightly expanded its scientific exchange program in the mid-1970s the Medical Research Council (MRC) which funds much of the Canadian activity represented in R.F.1:1, drastically cut its already modest visiting scientists program in the same period. Only 13 awards were given in 1972-73 (two foreign) and seven awards in 1975-76.

Co-authorship data were developed for the other research fronts as well: because of limited space, we have chosen only one research front (R.F.1:1) to illustrate how the indicator can be used.

Distribution of Canadian Publication Activity Among Sectors

Publication and co-authorship data were also aggregated by means of a standardized dictionary of research organizations within Canada. As at the international level, essentially three indicators have been generated with respect to the production of papers. These involve (1) changes in the organizational production of papers, (2) the analysis of specialization in terms of research profiles which distribute that production among research fronts, and (3) co-authorship data among institutions.

Again, these same distributions will become more qualitative and informative when we insert relevance values in place of output, as shown in the following chapter, but some illustrative material from the output data may be of interest.

The Canadian share (4.5%) of the world's scientific papers in the 85 research fronts was distributed among institutional sectors as shown in Table 2.4. This distribution is interesting in several respects. The distribution of Canadian activity in terms of publication is concentrated in the universities with a strong representation of federal government laboratories as well. A rough comparison with the distribution of activity in the United States can be made based on papers monitored for the SCI at ISI. The location dictionary used by Computer Horizons, Inc., placed about 68% of publications for 1979 in the university sector (including medical schools); results similar to Canadian activities. However, industrial institutions in the United States accounted for about 9% of their country's activity, while only about 2% of Canadian activity originated in the industrial sector (data not provided).[30]

Obviously, research in hospitals and clinics is a large and fundamental aspect of medical research in this country. It is often pictured as a subsidiary system of clinical teaching arrangements, internships, and joint appointments. But there are in fact 173 such research organizations, now publishing at about the same rate as all federal laboratories (though often in fields with higher publication rates, to be sure). Nevertheless, research in clinics amounts to something more than just an appendage on a few medical schools, and probably should be treated separately for survey and policy purposes. One could explore, for example, the implied research subsidy that must be contained in the transfer payment for hospitalization and health care.

Table 2.4 also includes some important information on possible trends in the dispersion of efforts and specialization within these sectors. The dispersion of publishing among university and industrial locations, many of which may be ineffectively small, has long been recognized as a problem for research policy in Canada. Normalizing these distributions, we can compare the degree of concentration, which is maximal for this measure at 0.5. As expected, the degree of dispersion is very great in both sectors, but contrary to various policies aimed at specialization and critical size, the dispersion of research activities would appear to be on the increase. This holds true in the federal sector as well, although the units are too aggregated to be particularly meaningful.

See References at end of text.

TABLE 2.4 Distribution of Canadian Activity by Sector

Sector	Papers		Units	Logi(1)
	number	per cent	number	
1974				
University	11,394	71.7	48	.334
Federal government	2,263	13.6	27	.410
Hospitals, including university clinics	1,571	9.9	146	.372
Business	354	2.2	142	.267
Provincial governments	202	1.3	50	.272
Non-profit organizations	214	1.3	32	.348
1978				
University	12,760	69.7	47	.331
Federal government	2,337	12.8	22	.384
Hospitals, including university clinics	2,327	12.7	173	.392
Business	404	2.2	172	.249
Provincial governments	249	1.4	47	.289
Non-profit organizations	225	1.2	36	.352

(1) This is a measure of the concentration of publication frequencies among locations. It varies on a scale from 0 to 0.5 such that if all papers tend to come from very few locations, the measure approaches its maximum.

This pattern of increasing dispersion of activity is generally repeated on the world scene for those fronts representing very established research areas, whereas the highly dynamic research of recent vintage appears to be concentrated in a few laboratories in a few countries.

Concentration of Publication Activity in Canadian Universities

Overall publication frequencies for particular institutions are not directly useful, for while there is no reason to expect a regional bias in coverage, variations in field coverage and publication rates would throw off any comparisons based on such a measure. Space will not permit presentation of location output matrices by journal front, but we examined the "research profile" for each location. An activity level research profile is a vector, or row from such a matrix, normalized to show the distribution of an organization's research among fronts. By way of summarizing the information on such profiles, measures of concentration of activity in 1974 and 1978 were computed as well (Table 2.5). For example, in 1978 the University of Toronto produced 2,002 papers or 15.7% of the Canadian university total of 12,760 (up from 15.1% in 1974). The University of Toronto's papers were distributed among 65 journal fronts in 1978, with a gini concentration of 0.341. An alternate, and perhaps more sensitive measure is to take the statistical entropy of the distribution: entropy = 3.586. Despite publishing in more fronts than in 1974, this measure indicates that research at the University of Toronto became more dispersed in the period. (Zero entries are taken into account here, in order to allow the measure to describe a degree of specialization.)

McGill University was, in fact, one of the most dispersed of all universities in 1974 (gini 0.341 in 61 fronts); by 1978, McGill was slightly more specialized at 0.361 in 61 fronts. A university publishing in 50 fronts or more, with this degree of dispersion, could be placed in the same category as Robert Gilpin placed the U.S. and the U.S.S.R. with his term a "research superpower", pursuing a world-class level of activity on all fronts.

The entropy values are perhaps more subtle than the gini, separating out 15 universities with profile entropies greater than 3.3. All participated widely in the system of research fronts, supported by their medical schools with clinical affiliations to sustain their research activities. The "TRIUMPH" facility (not shown in Table 2.5) of the University of British Columbia is of course very specialized, and was separated as a location along with the university clinics in order to preserve accuracy. [TRIUMPH is an atomic research facility jointly administered by three British Columbia universities; and it frequently appears as the given address of investigators from those locations.]

TABLE 2.5 Concentration of Publication Activity, by University(1)

	Number of journal fronts		Gini		Entropy	
	1974	1978	1974	1978	1974	1978
McGill University	61	61	0.341	0.361	3.574	3.436
University of British Columbia	60	64	0.343	0.330	3.571	3.648
University of Toronto	58	65	0.344	0.341	3.546	3.586
University of Alberta	58	62	0.347	0.337	3.539	3.602
University of Western Ontario	53	53	0.360	0.348	3.441	3.524
University of Saskatchewan	47	48	0.369	0.364	3.374	3.411
Queen's University at Kingston	44	48	0.373	0.371	3.343	3.346
University of Calgary	43	48	0.371	0.359	3.358	3.457
Dalhousie University	41	50	0.377	0.359	3.316	3.452
Université Laval	34	44	0.381	0.368	3.261	3.357
Simon Fraser University	33	33	0.415	0.406	2.907	3.028
University of Windsor	32	27	0.412	0.418	2.945	2.884
Université de Sherbrooke	29	25	0.406	0.419	3.027	2.889
University of Victoria	26	28	0.421	0.414	2.850	2.922
University of New Brunswick	24	24	0.420	0.422	2.872	2.832
University of Regina	18	21	0.421	0.416	2.748	2.866
Memorial University of Newfoundland	16	42	0.438	0.378	2.574	3.306
Université du Québec	16	28	0.436	0.417	2.540	2.875
Lakehead University at Sudbury	16	14	0.442	0.454	2.505	2.223
Brock University	16	19	0.444	0.431	2.493	2.689
University of Manitoba	14	55	0.440	0.374	2.515	3.320
Université de Montréal	14	50	0.437	0.364	2.533	3.422
École Polytechnique	14	14	0.447	0.441	2.428	2.501
St. Francis Xavier University	13	8	0.452	0.465	2.330	1.936
University of Lethbridge	13	14	0.452	0.445	2.328	2.444
Université de Moncton	12	9	0.442	0.460	2.396	2.101
Trent University	11	12	0.456	0.444	2.220	2.399

(1) Includes all institutions that published in at least 10 fronts in 1974.

Interaction Among Authors and Sectors and Distribution of Linkage Activity

As far as possible, Statistics Canada conventions were followed in allocating organizations among sectors so that merging of bibliometric and funding data for further industrial indicators will be possible. Thus, among the most prolific industrial research organizations are a number of Crown agencies operating within the standard industrial classification of industrial sectors. While only six of the 172 business organizations publishing in 1978 had a total of 10 or more papers in the 85 fronts, only half of them are strictly private-for-profit organizations (Xerox, Ayerst Laboratory and Bell Northern Research). The others are Ontario Hydro, IREQ Division of Hydro Québec, and the Pulp and Paper Research Institute of Canada (PAPRICAN). Ayerst published in 11 fronts and Xerox in nine; both were somewhat dispersed. Bell Northern Research and PAPRICAN were in eight fronts and Alcan in five. All others were in fewer fronts than that, and were of course specialized with high gini measures.

Similarly, the co-authorship data for locations are, for the most part, relevant to research policy within particular organizations. However, at the aggregate level, it is of general interest to look at the degree of interaction among sectors, as suggested by a measure of co-authored linkages. Several policy initiatives in recent years have addressed this area. Table 2.6 gives the overall numbers for 1978, and percentage allocations for 1974 and 1978. The table again shows the central importance of the university sector as a base from which collaborative interaction can be built. By far most of it is within the university sector and the health science complex of clinics and other institutions surrounding university medical schools. Several federal laboratories have been highly collaborative with the university sector, perhaps indicating the importance of some of their research facilities to university research, such as those at Atomic Energy of Canada Ltd. (AECL).

Universities were responsible for even more linkages in 1978 than in 1974, the situation for industry remained virtually unchanged. This is disappointing because several policy programs have tried to establish a closer link between university and industrial sectors for some time. These ties did increase absolutely in small numbers, but the resulting pattern remained unchanged. We examined these matrices for particular research fronts in applied science, and found the same to be true (data not provided). University/business linkages are developing in Applied Mathematics and Computer Science (R.F.14:47) for example, but the numbers are still very small. Similar small linkages are being established for Pharmacology (R.F.3:14, representing food chemistry and pharmacy), and Microbiology and Macromolecular Science (R.F.2:15). The numbers may indicate the movement and collaboration of isolated individuals, but this type of linkage has obviously not yet been successfully institutionalized.[31]

See References at end of text.

TABLE 2.6 Co-authorship Data: Intersectoral Linkages

	Univer- sity	Hospi- tals(1)	Federal govern- ment	Non- profit organ- izations	Business	Provin- cial govern- ments	Total
1978							
	number						
University	4,005	1,403	353	136	107	79	6,083
Hospitals(1)	1,403	856	23	26	7	8	2,323
Federal government	353	23	327	5	31	31	770
Non-profit organizations ..	136	26	5	14	-	1	182
Business	107	7	31	-	17	8	170
Provincial governments	79	8	31	1	8	17	144
Total	6,083	2,323	770	182	170	144	9,672
per cent							
University	41	15	4	1	1	1	63
Hospitals(1)	15	9	--	--	--	--	24
Federal government	4	--	--	--	--	--	8
Non-profit organizations ..	1	--	--	--	-	--	2
Business	1	--	--	-	--	--	2
Provincial governments	1	--	--	--	--	--	2
Total							100
1974							
	per cent						
University	40	15	4	2	1	1	62
Hospitals(1)	15	8	--	--	--	--	24
Federal government	4	--	4	--	--	--	8
Non-profit organizations ..	2	--	--	--	--	--	2
Business	1	--	--	--	--	--	2
Provincial governments	1	--	--	--	--	--	2
Total							100

(1) Includes university clinics.

Chapter 3

AN EVALUATION OF PAPERS

Methodology

The evaluation of relevance presented here results from an examination of all references in papers monitored by ISI in 1978. All articles, reviews and letters were included, as they do not bias the methodology. The largest part of the cost of generating indicators from this data base is initially reading the data base itself. Therefore, a minimal selection of cited years was necessary. By examining the cited years for each journal, and aggregating this for each class, a reasonable judgment on this point led to the selection of 1974 to 1976 for cited years. The measure used to inform this judgment is called vintage.[32] As an example, in computing the vintage measure for cited years in Core Biochemistry (R.F.1:1) we observed that 1978 papers in those journals cited 163 different years stretching back to 1543. As expected, the distribution was concentrated on recent years, and, the maximally cited year of this very active literature was only two years old. Looking backward from 1978, some 44,775 references (or 14% of the total) were to papers published after January 1976. The "half-life" for most of the literatures was reached at some point within 1975, and rates diminished radically behind that point. Therefore, 1974 to 1976 were the years selected, and thus for practical reasons 1974 and 1978 became the years for discussing possible trends in the output data in the previous chapter.

Based on their 1978 citation files, the relevance among papers from 1974 to 1976 was computed and summed for each paper. Some 1.4 million address records were then searched and standardized (for countries, and for locations within Canada). Relevant papers were then allocated to journal classes (but the total relevance of each paper to all other papers in the system was retained). For each research front all relevant papers with found addresses were rank ordered from greatest to least relevant and distributed on a curve against accumulated total relevance for that research front.[33] These curves are log-normal Bradford-Zipf type distributions which are very skewed toward a few papers that generate most of the relevance. (The usual descriptive statistics based on central tendency would therefore be inappropriate and misleading.)

Next the percentage shares of papers by country and organization of origin were computed for the whole relevance distribution of each research front, along with the upper decile of relevance, and the upper percentile. Even if a country's papers are over- or under-represented in the data base, it is possible to examine the change in its share of relevance among the upper decile or percentile of relevance from its share of relevance for the whole distribution and thus whether its papers in the research front may have made a significant contribution. The actual percentage shares for any given country are subject to several factors in addition to the quality of research. But changes in those shares moving through the distribution to the most relevant papers, represent a key indicator of the overall quality of a country's output in that group of journals. In addition, it must be recognized that regardless of the overall relevance of a country's contribution, individual investigators may contribute very significant work which will be submerged in the overall picture, but nevertheless should be examined. (Considerable detail on fine structure is provided at the end of the chapter.)

From the analyses which follow, we shall see that those countries contributing the most papers in the core research fronts of the system are the same few who manage to maintain and increase their shares in the top decile and percentile of the relevance distributions. This pattern repeats itself in other research fronts, and leads one to advance the reasonable hypothesis that in order to generate very high quality papers, it is necessary though not sufficient to produce a correspondingly high overall share of papers.[34] For large research communities, this means maintaining at least a corresponding share of relevance throughout the distribution.

For a discussion of international performance, the 26 research fronts with greatest total relevance have been selected, in order, without further investigation, to exclude those which might seriously be under-represented in the data base and, in particular, to avoid the problem of discussing the performance of a country which may have a strong but unmonitored journal for which its scientists generally reserve their best papers. In this case, where we are generally considering clusters of journals from the world mainstream, we know that under-represented countries in most cases reserve their best papers precisely for these journals. Therefore, if, in the central core of journals, there is a bias in these

See References at end of text.

distributions, it should work in favour of the upper decile performance of peripheral research communities. Nevertheless, this means that for international comparisons, we do not consider some important fields such as mathematics which were not sufficiently represented in the data base to accumulate the necessary share of relevance in the journal system. In the following discussion, the selected research fronts are considered as they were grouped into research fields.

The International Distribution of Highly Relevant Papers for Selected Fronts

Clinical and Biomedical Research. Throughout the six major medical and biomedical research fronts (i.e., Core Biochemistry, Core Medicine, Pharmacology and Clinical Chemistry, Cell Research, Gastroenterology, Surgery, and Immunology and Pediatrics), the United States dominates the picture in terms of its control of journals, large output and major presence among the most influential papers. Table 3.1 shows the international shares of relevance for all countries with at least 1% of total relevance in these research fronts, fractionally allocated among co-authored addresses where appropriate. It is difficult for U.S. increases in the upper deciles and percentiles to look impressive because of their very large initial shares of papers. Nevertheless, while their share of relevant papers in Cell Research (R.F.1:6) was 61%, they took 74% of the relevance in the top percentile of papers. This increase alone is roughly equal to the entire presence of the next five countries. France provided a small share of papers which performed extremely well; they were twice as important in the upper percentile compared to the whole relevance distribution.

Core Biochemistry (R.F.1:1). Although the United States' presence is large in the Core Biochemistry research front, the strengths of England, Sweden, Israel and Switzerland are evident from these data. Canadian papers overall were slightly less influential than those from other countries and we had less than our expected share of the top papers. Specifically, Canada's papers represented 3.6% of all relevant papers in Core Biochemistry (R.F.1:1) in 1974 and 3.1% in 1978. The Canadian share of papers in 1974 to 1976 was 3.2% but our share of total relevance for this journal group was only 2.9%. In the rank ordered distribution our share of the more relevant papers in the upper decile and percentile were 2.7% and 2.1% respectively.

The most influential paper in this research front, and indeed in the entire system of 1974-76 papers, was submitted from a research group at the University of Aberdeen, with two collaborating English authors. We now know that this paper initiated something of a revolution in many fields of biochemistry and medicine. It is interesting that the first author of the lead paper in R.F.1:1 (J. Hughes), also published a related document which turned out to be the most influential in the cluster of main medicine journals (R.F.1:2).[35] Because of their great influence and relevance on the whole system of papers, the 10 most relevant papers in this research front are identified.

1. "Identification of two related pentapeptides from the brain with potent opiate agonist activity", *Nature*, 258 (December 18, 1975), p. 577 (J.H. Hughes, T.W. Smith, H.W. Kosterlitz (Research Unit), Linda A. Fothergill (Department of Biochemistry, Marischal College, University of Aberdeen), B.A. Morgan (Reckitt & Colman Ltd., Pharmaceutical Div., Hull, U.K.), H.R. Morris (Department of Biochemistry, Imperial College, London)).
2. "Transmembrane control of the receptors on normal and tumor cells", *Biochimica et Biophysica Acta*, 457 (April, 1976), pp. 57-108 (Garth L. Nicolson, Salk Institute (San Diego), and Department of Biology, University of California at Irvine).
3. "Chromatin Structure: A Repeating Unit of Histones and DNA", *Science*, 184 (May 24, 1974), p. 868 (Roger D. Kornberg, Harvard University, and MRC Laboratory of Molecular Biology, Cambridge, England).
4. "A film detection method for tritium-labelled proteins and nucleic acids in polyacrylamide gels", *European Journal of Biochemistry*, 46, July 1974, p. 83 (William H. Banner, Ronald A. Laskey, MRC Laboratory of Molecular Biology, Cambridge, England).
5. "Cell Surface Proteins and Malignant Cell Transformations", *Biochimica et Biophysica Acta*, 458 (April 1976), p. 73 (Richard D. Hynes, Center for Cancer Research, Department of Biology, MIT).
6. "Thromboxanes: A new group of biologically active compounds derived from prostaglandin endoperoxides", *Proceedings, National Academy Sciences, U.S.A.*, 72:8, August 1975, p. 2994 (Mats Hamberg, Jan Svensson, Bengt Samuelsson, Department of Chemistry, Karolinska Institute, Stockholm, Sweden).
7. "Spheroid Chromatin Units (v Bodies)", *Science*, 183, 1974, p. 330 (A.L. Olins, D.E. Olins, Oak Ridge and University of Tennessee).

8. "Metabolic Activation of benzo(a)pyrene proceeds by a diol-epoxide", **Nature** (1974), v. 252, p. 236, pp. 326-328 (P. Sims, P.L. Grover, A. Swaislan, K. Pal, A. Hewer, Royal Cancer Hospital, Chester Beatty Research Institute, Institute for Cancer Research, Fulham Road, London, England).
9. "Detection of Specific Sequences among DNA fragments separated by Gel/Electrophoresis", **Journal of Molecular Biology**, 983 (1975), p. 503 (E.M. Southern, MRC Mammalian Genome Unit, Department of Zoology, University of Edinburgh).
10. "Cell surface protein partially restores morphology, adhesiveness, and contact inhibition of movement to transformed fibroblasts", **Proceedings, National Academy Sciences, U.S.A.**, April 1976, v. 73, p. 1217 (Kenneth M. Yamada, Susan S. Yamada, Ira Pastan, Laboratory of Molecular Biology, N. Cancer Institute, NIH, Bethesda, Md.).

Despite our somewhat disappointing overall performance, a Canadian paper ranked sixteenth in this research front. It was contributed by a group in the Division of Neurology of Montréal General Hospital Research Institute and McGill University.[36] The complex of medical research institutions in Montréal distinguished itself in several less influential journal classes as well. The distinction of MRC units in Britain suggests that a close study of their institutional development might be helpful in the development of our own research infrastructure.

Core Medicine (R.F.1:2). Within this journal group the United States again dominates throughout the relevance distribution. Compared with the results for Core Biochemistry, Japan and France have reversed their performance, and along with Sweden increased their shares of top papers. Canadian papers maintained their relative shares. We shall examine the performance of individual laboratories in the following section, but again, the most influential paper came from the University of Aberdeen (J. Hughes, "Isolation of an endogenous compound from Brain with Pharmacological properties similar to Morphine", **Brain Research**, 88:2, p. 295). Clinical affiliations appear to be important, with a small group of institutions in Britain and the United States contributing the most important papers.

Pharmacology and Clinical Chemistry (R.F.1:5). This medical group, consisting of some 29 journals in Pharmacology and Clinical Chemistry is in the same research field as Core Biochemistry, but papers in these journals did not influence papers in R.F.1:1 strongly enough to allow them to be clustered together. Canada does not have a journal in either of these classes, nevertheless, Canadian papers maintained their share of relevance and there appeared a high frequency of Canadian papers among the most relevant: two papers among the 10 most relevant, and five among the 60 most relevant papers. The two most relevant were:

- R.F.1:5:3 "Chemical nature of synaptic transmission in vertebrates" (**Physiological Reviews**, 54 (1974), p. 418), by K. Krnjevic, Department of Anaesthesia, McGill University.
- R.F.1:5:10 "Drug-induced prophylin biosynthesis, XV..." (**Biochemical Pharmacology**, 25 (1976), p. 687), by P.W.F. Fischer, R.O. Morgan, V. Krupa, and G.S. Marks, Department of Pharmacology, Queen's University at Kingston.

It is interesting that also prominent among this list was another paper from the University of Aberdeen group:

- R.F.1:5:4 "Purification and Properties of Enkephalin: The possible endogenous ligand for the morphine receptor" (**Life Sciences**, 16 (1975), p. 1753), by John Hughes, Terry Smith, Barry Morgan and Linda Fothergill, in this configuration, they are identified as a group in Research on Addictive Drugs, University of Aberdeen, Scotland.

Without having done an exhaustive merge of funding records with the bibliometric results, it should be pointed out that substantial MRC research grants can be associated with these top Canadian papers in R.F.1:1 and R.F.1:5, both before, as well as after, the period under investigation.

Cell Research (R.F.1:6) and Gastroenterology, Surgery (R.F.1:7). A subsidiary cluster of cell research journals (R.F.1:6) again displayed the particular strength of U.S. laboratories, along with those in France and Israel. One of the surgery groups (R.F.1:7), with an emphasis on gastroenterology journals, is concentrated in fewer countries; Japanese clinics are emphasized.

Immunology and Pediatrics (R.F.1:8). There was only one Canadian journal among all the journals represented by Table 3.1. It is the **Canadian Medical Association Journal** and it is part of Immunology and Pediatrics, a group of 34 journals primarily devoted to immunology, infection and diseases of children. The upper levels of the relevance distribution of this research front show the strength of Canada, Sweden, and more particularly of West Germany. This would seem to reflect the presence of a large number of German journals, however, as in Canada's case, this is not so. Germany has only one (relatively unimportant) journal in this group; the **European Journal of Immunology**.

Peripheral medical research fronts. Similar tabulations for the more weakly connected medical groups of journals forming field 2 are given in Appendix V Table 1. The strongest of these, Secondary Biochemistry (R.F.2:12), contains 31 journals in biology and psychology though it would be difficult to determine a particular subject area. The *Canadian Journal of Biochemistry* clustered in this group as the second strongest journal after the *Royal Society Proceedings in Biology*. Papers from Canada and France did particularly well here. The top paper in the group (*Cell Tissue Research* (1975) 157:423) was produced by a former member of the medical faculty at the University of Sherbrooke.[37] Eight of the top 10 papers appeared in the sixteenth journal, *Cell and Tissue Research* (New York).

See References at end of text.

TABLE 3.1 International Shares of Relevance in Clinical and Biomedical Research, 1978 Reference Year

Research front/country	Share of relevant papers(1)	Share of relevance	Share of top decile relevance	Share of top percentile relevance
	per cent			
Core biochemistry (R.F.1:1)				
United States	56.1	61.0	64.9	63.2
England	9.4	9.7	9.6	12.1
West Germany	4.7	4.0	3.1	0.5
France	4.6	3.7	3.3	3.7
Japan	3.7	2.7	2.2	0.4
Canada	3.2	2.9	2.7	2.1
Sweden	2.0	2.8	3.0	5.0
Netherlands	1.8	1.4	0.8	0.7
Israel	1.8	1.9	1.9	2.6
Italy	1.6	0.7	0.3	0.2
Switzerland	1.5	1.9	2.1	2.6
Australia	1.4	1.1	1.0	0.2
Scotland	1.0	1.1	1.2	2.1
Belgium	1.0	0.6	0.4	0.2
Core medicine (R.F.1:2)				
United States	70.0	70.0	71.5	70.8
England	10.6	8.9	7.7	7.9
Canada	3.4	3.3	3.0	1.9
Scotland	1.9	1.3	1.0	1.9
Japan	1.7	2.0	2.2	2.4
France	1.5	2.0	2.0	2.5
Sweden	1.3	1.9	2.2	3.3
Australia	1.2	1.4	1.4	1.0
West Germany	1.2	1.3	1.3	0.7
Pharmacology and clinical chemistry (R.F.1:5)				
United States	53.1	52.4	53.1	56.6
England	9.8	11.7	12.9	11.0
Canada	4.7	4.7	4.7	5.4
West Germany	3.6	3.8	3.3	0.6
Sweden	3.5	4.3	4.3	4.4
Switzerland	3.1	2.3	2.7	3.6
France	2.7	3.2	3.6	3.4
Japan	2.6	2.2	1.7	1.2
Italy	2.0	1.7	1.7	1.4
Netherlands	2.0	1.9	1.8	3.7
Australia	1.6	1.8	1.8	0.5
Scotland	1.4	1.3	1.0	0.2
Belgium	1.3	1.2	1.0	1.2
Denmark	1.0	1.3	1.2	2.2

See footnote(s) at end of table.

TABLE 3.1 International Shares of Relevance in Clinical and Biomedical Research, 1978 Reference Year -
Concluded

Research front/country	Share of relevant papers(1)	Share of relevance	Share of top decile relevance	Share of top percentile relevance
	per cent			
Cell research (R.F.1:6)				
United States	61.4	66.8	70.5	74.1
Japan	7.1	4.8	3.1	1.4
England	6.0	5.9	5.3	5.0
West Germany	5.1	4.2	3.9	0.7
Canada	3.6	3.3	2.8	2.4
France	2.4	2.2	2.5	5.0
Sweden	2.0	2.3	2.4	2.7
Australia	1.3	1.4	1.3	0.4
Israel	1.3	1.6	1.9	2.3
Netherlands	1.3	1.3	1.2	1.5
Italy	1.1	0.6	0.4	--
Switzerland(2)	(2)	(2)	(2)	(2)

Gastroenterology, surgery (R.F.1:7)

United States	72.4	73.8	74.2	78.5
England	11.4	10.5	10.5	10.5
Canada	3.7	3.9	4.0	2.6
Scotland	1.9	1.5	1.2	--
Japan	1.3	1.5	1.9	3.2
Sweden	1.1	1.2	1.3	0.9

Immunology and pediatrics (R.F.1:8)

United States	57.5	58.2	60.6	57.5
England	9.8	10.5	10.1	7.3
Canada	5.4	4.4	3.9	2.6
Sweden	3.7	3.7	3.6	6.1
West Germany	1.9	2.7	3.3	5.1
Japan	1.9	1.5	1.3	1.5
Australia	1.9	2.0	1.7	1.3
France	1.8	1.8	1.6	1.5
Scotland	1.8	1.7	1.3	--
Israel	1.5	1.4	1.3	1.0
Netherlands	1.3	1.4	1.2	1.8
Switzerland	1.3	2.1	2.6	4.6

(1) The addresses of relevant papers dated 1974, 1975 or 1976 were searched in the 74 to 76 corporate tapes, and those countries with at least 1% of fractionally allocated addresses are shown.

(2) Had less than 1% papers, but did well with them.

The **Canadian Journal of Microbiology** is in Microbiology and Macromolecular Science (R.F.2:15) along with several journals on polymer and macromolecular science. The Japanese have a strong presence here, and England and France showed exceptional influence among the top papers. The Canadian participation here lacked distinction.

While Canada's publication level increased by 4.5% over the 1974-78 period within the Clinical Medicine, Reproductive Biology group (R.F.2:46) our share of world activity declined (from 3.0% to 2.1%). Nevertheless, Canada contributed 3.1% of the relevant papers and 4.3% of the top percentile of relevance for this group. Participation by England, West Germany, Sweden and Denmark are notable.

Applied Physics. The third field to cluster included the research fronts of Core Physics (R.F.3:4), Chemical Physics (R.F.3:9), Solid State Physics (R.F.3:10) and Pharmacology (R.F.3:14). The latter class includes journals in toxicology and analytical chemistry. There are two Canadian journals in the field: R.F.3:10 includes the **Canadian Journal of Physics** and R.F.3:14 includes the **Canadian Journal of Physiology and Pharmacology**. Table 3.2 presents the international shares of relevance.

Canadian papers were strong in both the Core Physics (R.F.3:4) and Solid State Physics (R.F.3:10) research fronts. The Core Physics journals also published very strong U.S. and West German papers; and while here, as elsewhere, papers from the Soviet Union are not monitored heavily, the importance of their contributions is still evident.

One of the Soviet papers in Core Physics, by A.M. Polyakov of the Landau Institute of Theoretical Physics in Moscow, was third in influence. Professor Ajzenberg-Selove from the Department of Physics at Pennsylvania published the two most influential papers. Two others came from Cornell, while Princeton, MIT and Harvard were represented in the inner 10, along with a large international group (France, United States, Italy) based at Berkley and which used the Stanford linear accelerator. Canadian addresses were very prominent among the top percentile. Some of these will be noted in the following section. The AECL laboratory at Chalk River published the strongest Canadian paper (R.F.3:4:31), one by J.C. Hardy and I.S. Towner.

As noted in the previous chapter, the level of Canadian participation in Solid State Physics (R.F.3:10) declined by 4.8% from 1974 to 1978. This group, which includes journals in solid state and low temperature physics, quantum electronics and the physics of surfaces, represents an area which is important to our electronics industry. Canadian papers showed particular strength in this group, and the declining activity might turn out to be costly. The United States, Japan, and England were strong performers in this area. The exceptional influence of papers from Czechoslovakia in chemical physics and applied chemistry should also be noted.

Some "noise" was introduced into the analysis of physics papers. A surprising degree of cited work in particle physics (part of Core Physics) is in the form of abstracts. This could be due to a number of factors including the delay time for formal articles, the depth of acceptance and understanding of given procedures within well formed invisible colleges as well as the rapid development of work in this field. In any case more than one influential abstract might appear on the same page, inflating the relevance evaluation of both to some extent. This source of noise is random and does not predominate over normal papers, hence the overall shares should not be altered (although co-authorship data for Core Physics would be misleading).

Core Chemistry (R.F.4:3). It was noted before that Core Chemistry, the third strongest cluster of journals in the system, formed a research field by itself, exerting wide influence throughout the system. This group (see Table 3.3), represents an area of traditional strength for West Germany, going back to the institutionalization of university-industry linkages in the last century. It had 9% of the relevant papers for 1974-76, 15% of all relevance and 25% of relevance in the top percentile. Britain, with a much smaller share, also displayed particular strength among the more relevant papers. Canada has a strong journal in this class, and contributed a substantial share of papers, but they did not, as a group, influence the rest of the system significantly. Canadian output declined by 3% in the period 1974 to 1978, while West German output increased by 43%. Five of the top 10 papers came from West Germany, and there were contributions from the U.S., the U.S.S.R. and Japan.

Without formulating the argument in detail, the reader is reminded that many of the numbers presented in this chapter seem to support the hypothesis mentioned earlier (i.e., that it appears to be necessary to field significant numbers of researchers in order to cultivate excellence among them). "Cultivation", however, is a term that conceals a large number of institutional and policy variables.

TABLE 3.2 International Shares of Relevance in Applied Physics, 1978 Reference Year

Research front/country	Share of relevant papers(1)	Share of relevance	Share of top decile relevance	Share of top percentile relevance
	per cent			
Core physics (R.F.3:4)				
United States	52.5	64.1	66.8	67.7
West Germany	7.3	6.7	6.5	9.5
France	6.8	5.4	5.1	4.8
Japan	6.7	3.5	1.9	0.6
England	5.6	5.0	4.8	3.2
Switzerland	3.2	2.0	1.8	0.2
Canada	2.9	2.4	2.4	4.2
Italy	2.1	1.3	1.3	1.0
Israel	1.4	1.8	2.0	2.0
Netherlands	1.3	1.1	1.1	1.9
U.S.S.R.	1.3	1.0	1.1	2.0
India	1.3	0.8	0.5	0.2
Denmark	1.0	0.9	0.9	1.0
Chemical physics (R.F.3:9)				
United States	22.3	25.3	24.7	20.3
Japan	10.3	8.7	9.6	10.6
West Germany	9.2	11.2	10.8	4.8
England	8.0	8.4	7.9	7.9
France	6.6	5.7	5.4	4.9
Czechoslovakia	6.3	5.6	6.2	14.2
Australia	6.1	5.6	5.5	9.1
Italy	4.7	3.8	4.0	4.8
Canada	4.6	4.7	4.4	2.0
Netherlands	3.9	2.9	1.8	--
India	3.0	2.1	1.9	1.0
Israel	1.7	1.3	0.7	--
Switzerland	1.3	1.1	1.1	--
East Germany	1.3	1.0	0.8	--
U.S.S.R.	1.2	0.8	0.6	1.2
Sweden	1.2	1.8	2.4	5.4
Solid state physics (R.F.3:10)				
United States	42.0	43.7	47.6	56.4
Japan	11.3	11.6	11.1	10.9
West Germany	9.0	7.7	6.0	1.5
France	7.0	5.5	4.5	2.3
England	5.7	8.4	8.6	9.6
Canada	5.6	6.0	6.2	7.1
U.S.S.R.	2.1	1.0	0.7	0.3
Italy	1.8	1.1	0.9	0.2
Netherlands	1.7	2.1	2.2	1.4
India	1.5	0.8	0.5	0.1
East Germany	1.4	0.7	0.3	--
Poland	1.1	0.6	0.3	0.3
Switzerland	1.0	0.8	0.6	--
Pharmacology (R.F.3:14)				
United States	55.9	38.9	35.7	35.0
Canada	6.4	6.2	6.4	4.0
West Germany	5.4	5.6	5.4	7.3
England	5.2	5.8	5.3	4.6
Japan	3.3	4.0	4.3	4.0
Sweden	2.3	3.4	3.5	4.1
Italy	2.2	2.7	2.9	2.4
India	2.2	3.4	4.0	2.2
France	1.6	3.3	3.7	4.6
Netherlands	1.4	2.2	2.2	0.6
Australia	1.2	2.0	2.0	1.1
Czechoslovakia	1.2	2.7	2.9	5.2
Switzerland	1.2	1.8	1.9	2.2
U.S.S.R.	0.4	2.4	3.0	4.6
Poland	0.5	2.1	2.6	4.6
Hungary	0.6	1.8	2.0	4.1

(1) The addresses of relevant papers dated 1974, 1975 or 1976 were searched in the 74 to 76 corporate tapes, and those countries with at least 1% of fractionally allocated addresses are shown.

TABLE 3.3 International Shares of Relevance in Core Chemistry (R.F.4:3), 1978 Reference Year

Country	Share of relevant papers(1)	Share of relevance	Share of top decile relevance	Share of top percentile relevance
	per cent			
United States	53.2	49.3	45.8	42.7
Japan	9.7	6.9	6.3	8.9
West Germany	8.7	14.6	17.2	25.2
Canada	7.4	6.2	5.5	3.6
France	4.1	4.7	5.3	3.4
Switzerland	2.7	2.1	1.7	0.4
England	2.5	3.8	4.6	5.7
Italy	2.4	2.5	2.8	2.7
Israel	1.3	0.9	0.6	0.4
Netherlands	1.0	1.4	1.8	0.4

(1) The addresses of relevant papers dated 1974, 1975 or 1976 were searched in the 74 to 76 corporate tapes, and those countries with at least 1% of fractionally allocated addresses are shown.

Chemical Analysis and Plant Biology. The four research fronts comprising field 5 (see Table 3.4) involve areas of Chemical Analysis and Plant Biology. This is a traditional area of strength in Canadian agricultural research. Though we have no journal in the Physical Chemistry group (R.F.5:20) our papers in chemical analysis and spectroscopy were particularly strong, as were papers from both East and West Germany. In comparing the results of this group with Physical Chemistry: U.S.S.R. (R.F.5:25) the effects of the relative isolation of journals and research in the Soviet Union are apparent (at least in this area of chemical analysis). Even though the Soviet journals are frequently translated they almost define their own research front. Language barriers do not appear to have resulted in similar separations among western countries. Occasionally there are areas, like Physical Chemistry, which include strong participation from Eastern Europe. The Soviet Union is not strongly enough represented in the data base to examine this aspect thoroughly.

To conclude this section on international performances in research, the following comments for specific research fronts are noted and the reader is directed to Appendix V for the supporting data.

Main Mathematics (R.F.6:17) (data not provided) under-represents the Soviet Union, much of Europe and many of the newer journals and therefore, it did not generate sufficient relevance to be among the groups considered internationally. However, we note that Canada's level of activity and world share declined significantly despite the strength of its papers; we had 5.1% of total relevance and 11% of the top percentile of relevance, a paper from the University of British Columbia placing second among the most relevant.

The cluster of Applied Mathematics, Secondary Physical Applications (R.F.6:30) includes several international mathematics journals. If coverage had been more complete, one assumes that this cluster would have become differentiated in the analysis. The United States and Italy are exceptionally strong in this group (see Appendix V Table 2). However, it does contain several specialties, and several of the most influential papers are in plasma physics. The citation characteristics of this area may be sufficiently different from the papers in applied mathematics to have overshadowed their importance.

The journal group, Chemical Engineering (R.F.7:34) (Appendix V Table 3) contains a strong contribution from India. Canadian papers were particularly influential in Photo-chemistry, Applied Physics (R.F.7:41) covering photo-chemistry, mass spectrometry and computer physics.

Geology and Astrophysics (R.F.8:13) contains the main journals in geophysics, which have been joined in recent years by journals in astrophysics. The importance of space sciences for geology no

TABLE 3.4 International Shares of Relevance in Chemical Analysis and Plant Biology, 1978 Reference Year

Research front/country	Share of relevant papers(1)	Share of relevance	Share of top decile relevance	Share of top percentile relevance
	per cent			
Plant biology (R.F.5:11)				
United States	36.1	36.6	38.9	45.4
England	12.3	15.5	14.9	15.2
Canada	8.3	7.6	6.3	0.5
West Germany	7.4	19.0	10.0	16.7
Japan	7.0	5.9	6.2	4.8
Australia	3.5	3.9	3.8	1.4
India	3.0	2.3	2.9	1.7
France	2.6	2.6	2.8	1.8
Israel	2.5	2.7	2.9	6.0
Scotland	2.4	2.4	1.6	1.4
Wales	1.3	1.4	1.0	--
Netherlands	1.2	1.2	1.4	--
Italy	1.1	0.4	0.4	--
Sweden	1.1	1.1	0.9	--
Physical chemistry (R.F.5:20)				
United States	20.6	24.5	25.4	15.0
France	16.0	13.8	14.0	12.4
West Germany	12.7	12.8	13.0	28.4
England	8.4	7.5	5.6	7.2
East Germany	7.5	7.9	8.7	13.4
Italy	6.2	4.8	5.4	1.5
Canada	2.9	3.9	3.9	7.6
Austria	2.7	2.4	2.0	1.3
Japan	2.4	2.4	2.1	--
India	1.5	0.9	1.0	--
Netherlands	1.3	2.4	2.9	--
Australia	1.2	1.0	0.6	--
Sweden	1.2	1.7	2.0	--
Norway	1.2	1.5	1.3	1.4
Belgium	1.1	0.5	0.1	--
Switzerland	1.1	1.3	1.2	--
Physical chemistry: U.S.S.R. (R.F.5:25)				
U.S.S.R.	64.6	59.5	61.0	83.0
U.K.S.S.R.	8.8	7.7	7.4	8.0
United States	5.5	6.5	5.9	--
England	2.1	3.0	3.0	1.1
Japan	2.1	1.5	0.8	--
France	1.9	3.2	3.4	--
Italy	1.3	3.1	3.9	--
Netherlands	1.1	1.7	1.6	--
B.E.S.S.R.	1.0	1.2	1.4	1.2
West Germany	0.9	1.9	2.1	1.2
Canada	0.8	0.9	0.6	--
Plant biology and soil science (R.F.5:29)				
United States	55.8	55.1	57.0	59.9
England	8.9	11.3	11.7	17.5
Canada	7.9	8.4	8.8	5.8
Australia	5.3	4.8	3.6	4.6
West Germany	4.1	4.2	3.2	--
Scotland	2.1	2.1	1.5	--
India	1.9	0.8	0.3	--
Israel	1.8	1.7	1.7	--
Netherlands	1.1	1.1	1.4	--

(1) The addresses of relevant papers dated 1974, 1975 or 1976 were searched in the 74 to 76 corporate tapes, and those countries with at least 1% of fractionally allocated addresses are shown.

doubt upsets the traditional field in which Canada once predominated. Now one finds particular influence from the United States, England and Australia (Appendix V Table 4).

Western Europe has a greater presence in the area of materials research and applied physics (Physics of Materials (R.F.9:23), see Appendix V Table 5), with particular influence from England, France, Sweden and the Netherlands. The Canadian share of papers here was large, but their influence was negligible. Subsequent to the time period under study, our modest university efforts were supplemented by the development of federally supported laboratories in this area.

Applied Mathematics and Computer Science (R.F.14:47) contains some 37 journals in computer science and related mathematics, but again, it did not generate sufficient relevance to be considered a solid base for international comparisons. It is noted for Canada that despite our world share drop in published papers we showed particular strength in the papers contributed: we took 7.6% of total relevance, held on to 6% through the top percentile, and contributed one of the inner 10 papers (data not provided).

Finally, Applied Statistics, Population Biology (R.F.10:50) contains a large mixture of journals in food science, biometrics and other statistical applications. Papers from the United States performed strongly in the distribution, along with those from England, France, Australia and Denmark. Canada had a substantial share and maintained this throughout the relevance distribution (see Appendix V Table 6).

This completes an overview of the research fronts considered suitable for an evaluation of papers on an international basis. We turn now to a closer examination of Canadian activities, to which some reference has already been made.

In Search of Excellence in Canadian Science

The Canadian share of relevant papers (for which addresses were found) for 1974-76 amounted to 28,410 papers or 4.5%. In an overall distribution of relevance, 2,851 Canadian papers were in the top decile and 252 in the top percentile. For this part of the analysis of Canadian activity, the relevance factor for each paper was fractionally allocated among all given addresses. For all research fronts, this fractional relevance was then aggregated for each standardized Canadian address over the whole distribution, and then over the top decile and the top percentile of the curve. These values thus sum up to the values given for Canada as a whole in the previous section.

Since the frequencies of most important papers by Canadian organizations in any given research front may be small it is more useful to give a ranking of institutions in the top percentile of relevance and the actual frequencies of address records rather than percentage shares as in the international presentation. All institutions appear if they have at least part of a paper in the top percentile of world relevance for the class.

We have noted in previous discussions that while Canadian shares of relevant papers were substantial in most research fronts along with shares of total relevance, in only seven of the 32 international research fronts did we substantially increase our expected share of the upper decile and percentile of relevance. On the surface this would seem to narrow considerably the search for overall excellence in world terms. In any case, as a first approximation in the search strategy we may search for data on our stronger institutions by looking first at these few research fronts where Canadian activity as a whole was taken particularly seriously. Complete data on the performance of Canadian laboratories in the top decile of relevance can be found in Appendix V Table 7.

Core Biochemistry (R.F.1:1). Within the area of Core Biochemistry, some 88 separate Canadian organizations contributed relevant papers; the University of Toronto appeared most frequently (16.6%) followed by McGill University (8.5%), University of Alberta (8.4%) and the Ottawa laboratories of the NRC (4.8%). However, McGill had a very strong paper and this was sufficient to put it first in a ranking of institutions for the very top percentile of relevance in this group. Actually AECL appeared most frequently in the top percentile, but the fractionally allocated relevance of its five papers did not equal that of the single McGill paper which ranked sixteenth in world relevance. The AECL paper ranked number 140 in the world research front. Their respective organizations ranked two and 13 in the top decile, and one and four in the top percentile. No effort has been made to normalize these results with the numbers of investigators, or the numbers of overall contributions in the front, but none of the laboratories in the top percentile is small or peripheral in the Canadian community. Table 3.5 shows the ranking of the top seven institutions in R.F.1:1. Details on the 32 institutions with papers in the top decile can be found in Appendix V Table 7.

While one would expect these areas of medicine and biochemistry to be dominated by those universities with medical schools and associated teaching clinics, it is notable that two federal laboratories are among the select seven institutions. The Ontario Cancer Institute also appears frequently as an

address of exceptional papers in many of the fronts of medical journals. While we do not often find isolated and small facilities, it can be seen from these and results to follow, that the highest quality of output is not at all a simple function of size, level of output or level of funding.

TABLE 3.5 Canadian Institutions in the Top Percentile of Relevance in Core Biochemistry (R.F.1:1), 1978 Reference Year

Canadian rank/institution	Overall frequency(1)	Frequency in top decile	Frequency in top percentile
1 McGill University	144	18	1
2 University of Toronto	282	40	4
3 National Research Council, Ottawa	82	12	2
4 Atomic Energy of Canada Ltd., Chalk River, Ont.	8	5	5
5 Université de Montréal	71	9	1
6 Ontario Cancer Institute, Toronto	16	6	1
7 University of Guelph	20	7	1

(1) Frequency refers to the number of appearances of an organization's address. All addresses on each paper are taken into account and the relevance measure is fractionally allocated.

Pharmacology and clinical chemistry (R.F.1:5). In R.F.1:5, one can find many papers with titles similar to the most influential in Core Biochemistry (R.F.1:1), but they do not attract the same wide attention here. For example, the Hughes group at Aberdeen had produced the top paper in R.F.1:1 which, as noted, initiated a large response throughout the system. Hughes alone also wrote a similar and very strong paper in Core Medicine (R.F.1:2). In R.F.1:5, the same group produced another paper on enkephalin and the releasing mechanism for morphinelike substances from the brain. This time, publishing in **Life Sciences**, a British clinical journal, they perhaps reached a distinctive group within the large community of biomedical research, and the paper turned out to be the fourth most influential in the research front. It was nosed out this time by a McGill paper "Chemical Nature of Synoptic Transmission in Vertebrates 2", by K. Krnjevic (**Physical Review**, 1974/54/418). A group from the Department of Pharmacology at Queen's University, Kingston, produced a paper ranked No. 10 (**Biochemical Pharm.**, 1976/25/687). This again shows that even two years is sufficient time for the relevance measure to pick up and indicate the impact of a paper in such a dynamic area (it also shows that the measure is not sensitive to the size-of-citation-file problem that plagues other impact measures). The fact that Queen's University has four appearances in the upper percentile is due to a co-authorship of four on their strongest paper.[38] Business also puts in an appearance in this front with a paper from Ayerst (pharmaceutical) Laboratory, Montréal. The distance of Canadian researchers from industrial pharmaceutical laboratories would seem to be costly here as well as in more fundamental areas of biochemistry.

Four of the top 30 papers in journals of pharmacology and clinical chemistry were by Canadian university staff. Some 94 Canadian organizations contributed relevant papers, though the distribution of relevance was quite concentrated among them ($\log i = 0.409$, entropy = 3.095). McGill again produced the strongest showing in both the top decile and percentile, this time from a base of a higher level of activity, more in line with the University of Toronto. It is shown here again that performance is not a simple reflection of size. Some 31 organizations had a level of activity equal to or greater than the Ontario Cancer Institute, and the University of Windsor. However, while both institutions were among the smallest contributors in numbers, both were among the strongest in terms of relevance. Table 3.6 shows the ranking of the top seven institutions in R.F.1:5.

See References at end of text.

TABLE 3.6 Canadian Institutions in the Top Percentile of Relevance in Pharmacology and Clinical Chemistry (R.F.1:5), 1978 Reference Year

Canadian rank/institution	Overall frequency(1)	Frequency in top decile	Frequency in top percentile
1 McGill University	133	7	1
2 Queen's University at Kingston	43	9	4
3 University of Saskatchewan	25	7	1
4 University of Toronto	159	23	2
5 Ontario Cancer Institute, Toronto	7	1	1
6 University of Windsor	3	1	1

(1) Frequency refers to the number of appearances of an organization's address. All addresses on each paper are taken into account and the relevance measure is fractionally allocated where appropriate.

Secondary Biochemistry (R.F.2:12). The journals of cell biology, protein chemistry and physiological psychology represent an area in which Canada had a large world share and increased that share appreciably in the upper relevance percentile.

There were 70 organizations involved in this front. Relevance was somewhat dispersed (gini = 0.358 and entropy = 3.255). The Université de Sherbrooke's participation level was not large (there were 16 organizations with more papers) but the top world paper in this journal front was produced at Sherbrooke. Table 3.7 shows the ranking of the nine institutions in the top percentile of R.F.2:12.

TABLE 3.7 Canadian Institutions in the Top Percentile of Relevance in Secondary Biochemistry (R.F.2:12), 1978 Reference Year

Canadian rank/institution	Overall frequency(1)	Frequency in top decile	Frequency in top percentile
1 Université de Sherbrooke	16	4	1
2 University of Toronto	148	12	2
3 Carleton University	20	4	1
4 University of Western Ontario	32	4	2
5 Sick Children's Hospital, Toronto	22	3	1
6 Université Laval	24	10	1
7 Ontario Cancer Institute, Toronto	2	1	1
8 Laval Centre Hospital	1	1	1
9 Simon Fraser University	13	1	1

(1) Frequency refers to the number of appearances of an organization's address. All addresses on each paper are taken into account and the relevance measure is fractionally allocated where appropriate.

One could speculate that the high performance levels of such smaller research centres as the Ontario Cancer Institute and the Laval Centre Hospital is due to their involvement with much larger and complementary research complexes. Thus, high levels of activity might be maintained, for example, in the context of teaching and health care functions at the University of Toronto and the Sick Children's Hospital, while specialized centres in the same complex may become a focus for excellence. In any case, the influence of Laval papers was also strong in relation to its overall contribution.

Clinical Medicine, Reproductive Biology (R.F.2:46). Canada had 3.1% of the papers, and 4.3% of top percentile relevance in the much more loosely connected research front of R.F.2:46, which contains journals in clinical endocrinology, gynecology and cell genetics (Table 3.8). Some 44 Canadian

organizations contributed relevant papers, but only two of them were in the top percentile: McGill University and the University of Manitoba. Though there are 49 loosely connected journals in the group, representing several research areas, publication and citation rates would appear to be low. Toronto only had 30 appearances in total, followed by Western with 16 and Manitoba and Sherbrooke with 14 each. The performance of other organizations not in the top percentile can be found in Appendix V Table 7. McGill managed to rank highest in the top percentile on the base of just 11 appearances, and this seems to be characteristic of its excellent performance in several medical fields.

TABLE 3.8 Canadian Institutions in the Top Percentile of Relevance in Clinical Medicine, Reproductive Biology (R.F.2:46), 1978 Reference Year

Canadian rank/institution	Overall frequency(1)	Frequency in top decile	Frequency in top percentile
1 McGill University	11	3	1
2 University of Manitoba	14	1	1

(1) Frequency refers to the number of appearances of an organization's address. All addresses on each paper are taken into account and the relevance measure is fractionally allocated where appropriate.

Leaving medicine and passing on to the research fronts in field 3 concerned with applied physics, one can again observe the overall excellence of Canadian contributions, particularly those from government laboratories.

Applied Physics. Tables 3.9 and 3.10 present data for Core Physics (R.F.3:4) and the key group of journals in physical chemistry, quantum electronics and mathematical physics (R.F.3:10).

We repeat a note of caution in interpreting the top percentile of Core Physics: the citation of many papers in the form of physics abstracts has introduced some noise (which we believe to be random) where two exceptional abstracts might have been published on the same page. This possible source of error might be misleading for very small groups of articles, such as in the top percentile. Nevertheless, the ordering of locations is probably accurate. Assuming this to be true, physics appears to be in good shape at all of these locations, particularly at McMaster, AECL and Laval.

TABLE 3.9 Canadian Institutions in the Top Percentile of Relevance in Core Physics (R.F.3:4), 1978 Reference Year

Canadian rank/institution	Overall frequency(1)	Frequency in top decile	Frequency in top percentile
1 McMaster University	97	9	6
2 Université de Montréal	42	2	2
3 Atomic Energy of Canada Ltd., Chalk River, Ont.	124	9	1
4 Université Laval	23	4	2
5 McGill University	49	5	1
6 University of Manitoba	39	4	1
7 University of Toronto	125	12	2

(1) Frequency refers to the number of appearances of an organization's address. All addresses on each paper are taken into account and the relevance measure is fractionally allocated where appropriate.

In R.F.3:10, Canada seems to have demonstrated considerable depth and influence throughout the relevance distribution, involving laboratories from all sectors. We had 16 of the top 100 papers (ranked Nos. 22, 28, 31, 32, 43, 44, 45, 48, 52, 58, 59, 63, 71, 72, 78, 83). Relevant research in this area

of applied physics was distributed among 67 Canadian organizations and this again is comparatively dispersed (gini = 0.377, entropy = 2.982). The University of Toronto, NRC, University of Windsor, and AECL recorded strength, but the fact is most notable that 29 Canadian organizations were in the top decile from all sectors, including six business firms (see Appendix V Table 7).

TABLE 3.10 Canadian Institutions in the Top Percentile of Relevance in Solid State Physics (R.F.3:10), 1978 Reference Year

Canadian rank/institution	Overall frequency(1)	Frequency in top decile	Frequency in top percentile
1 University of Toronto	121	19	4
2 National Research Council, Ottawa	136	14	4
3 University of Windsor	18	3	1
4 Atomic Energy of Canada Ltd., Chalk River, Ont.	57	9	2
5 University of Saskatchewan	7	3	2
6 Queen's University at Kingston	29	5	1
7 Trent University	2	2	2
8 University of Western Ontario	38	8	5
9 McMaster University	101	14	2
10 Université de Montréal	48	9	2
11 University of Manitoba	23	3	1
12 University of Ottawa	13	1	1

(1) Frequency refers to the number of appearances of an organization's address. All addresses on each paper are taken into account and the relevance measure is fractionally allocated where appropriate.

As shown in Table 3.10, the dozen organizations in the top percentile contain no industrial firms, and are led by strong physics divisions in two federal laboratories and two universities, Toronto and Windsor. In addition, one observes a particularly strong performance of papers from the University of Saskatchewan on the basis of only seven appearances.

In Pharmacology (R.F.3:14) we again see the strength of government laboratories in environmental and health-related regulatory areas. The top paper in the world in this front came from the Canadian Centre for Inland Waters at Burlington.[39] (See Appendix V Table 7.)

Tables 3.11 and 3.12 present similar information for the other two research fronts in which Canadians had substantially increased their share of top relevance: Physical Chemistry (R.F.5:20), and Photo-chemistry, Applied Physics (R.F.7:41). Both of these research fronts include journals in applied physics and chemistry involving instruments for molecular spectroscopy and mass spectrometry. R.F.5:20 is a very cosmopolitan front, but perhaps because of the specialized instruments involved, only 37 organizations contributed relevant papers (gini = 0.321, entropy = 2.871). The University of British Columbia contributed most of them (40), but only five were in the top decile and none in the top percentile. The Universities of Toronto and Western Ontario were next, but the numbers are very small. We have already noted that scientists at these universities publish fairly extensively in main physics or main chemistry, and not so frequently in this more applied or chemical analysis group of journals in photo-chemical applications. In any case, papers from Waterloo and Manitoba performed well for their small numbers, with strength indicated for the chemistry departments at NRC and Guelph.

See References at end of text.

TABLE 3.11 Canadian Institutions in the Top Percentile of Relevance in Physical Chemistry (R.F.5:20), 1978 Reference Year

Canadian rank/institution	Overall frequency(1)	Frequency in top decile	Frequency in top percentile
1 University of Waterloo	10	2	2
2 University of Guelph	11	8	2
3 National Research Council, Ottawa	13	7	1
4 University of Manitoba	7	2	2
5 University of Toronto	14	2	2

(1) Frequency refers to the number of appearances of an organization's address. All addresses on each paper are taken into account and the relevance measure is fractionally allocated where appropriate.

TABLE 3.12 Canadian Institutions in the Top Percentile of Relevance in Photo-chemistry, Applied Physics (R.F.7:41), 1978 Reference Year

Canadian rank/institution	Overall frequency(1)	Frequency in top decile	Frequency in top percentile
1 University of Ottawa	7	3	3
2 University of Toronto	20	7	2

(1) Frequency refers to the number of appearances of an organization's address. All addresses on each paper are taken into account and the relevance measure is fractionally allocated where appropriate.

This search for excellence in Canadian papers would seem to be most promising for areas where the class of journals is fairly homogeneous, and within or close to the mainstream of world research in their field. It is no particular consolation to publish the strongest papers in a subsidiary class of journals that the world treats as peripheral. However, in this section, we have thus far only searched in research fronts where Canada as a whole has done well, and this undoubtedly means we have cast the net too narrowly. It remains always possible that where Canadian papers perform poorly taken all together, some few might still prove exceptional. Moreover, since we are now only looking at Canadian locations, we can be interested in all research fronts where Canadians publish substantially, even if some foreign countries or some research specialties are not well represented in those fronts.

Therefore, Appendix V Table 7 provides similar data, for all research fronts in which Canada at least participated in the top decile of relevance. The research fronts are presented by fields. The data are organized essentially in the same form as Tables 3.5 to 3.12, except that rank and frequency are provided for both the top decile and the top percentile of relevance. Again, with respect to the location dictionary, hospitals and clinics were separated from universities for consistency, even when their affiliation with the medical school is strong. Every address included on each paper was included here; the frequency counts are for appearances of that address in a particular part of the relevance distribution.

It is easy for the Canadian reader to scan the organizations on Appendix V Table 7, comparing expectations with results. Surprises come up in each research front. For example, in R.F.1:6 covering cell biology and cancer research, Canada had papers ranked 24, 60, 81 and 85. The University of Toronto with 17 appearances, ranked first in the top decile, produced only one of these papers (No. 85), and ranked fifth in the top percentile. In fact, researchers at Université Laval produced two (No. 24 and No. 81); University of British Columbia had another. The small but excellent contribution from the Ontario Cancer Institute is notable again in this research front.

In Core Medicine (R.F.1:2), Canada had three of the top 100 world papers (the best one, No. 3, coming from the University of Calgary). This single paper was just enough to place Calgary among the 10 Canadian organizations in the top percentile of world relevance (co-authorship forces some of the

relevance of exceptional papers to be assigned elsewhere, hence the Université de Montréal, also with a single paper, placed fourth in the top percentile).

From the point of view of searching for excellence in research organizations as opposed to single investigators, one could look for a reasonable level of appearances in the top decile, and then compare the share of top decile papers that make it into the top percentile. Thus, for the previous cluster of Core Biochemistry (R.F.1:1), all five of AECL's top decile papers were also in the top percentile, while only one in the 18 from McGill. In Core Medicine, Toronto's Hospital for Sick Children had three in eight, and the Royal Victoria Hospital in Montréal had three in 10. But, should one consider it a mark for or against the Royal Victoria that they had two extra papers in the top decile? One's answer to such a dilemma will at the same time betray one's assumptions with respect to the Ortega Hypothesis (i.e., Reference 34).

In Core Chemistry (R.F.4:3), despite a disappointing national performance, we had four papers in the top 100 (Nos. 12, 14, 27, 59), and nine universities had 10 or more appearances in the top decile. The surprise here, in view of their funding and size, is the strength of the Universities of Alberta and Western Ontario, in a chemistry class dominated by physical chemistry. On an individual basis we have not found that funding levels in this area correspond with performance.

Though we could not discuss mathematics in an international context Main Mathematics (R.F.6:17) does contain 12 important international journals in this field. Canada produced a very significant paper here, ranked second in the world (**Transactions, American Mathematical Society**, 205 (1975), p. 247); "Generalized Gradients and Applications", by Frank Clarke at the University of British Columbia.

At the same time, the data for Geology and Astrophysics (R.F.8:13) seem to confirm that our peripheral relationship in astrophysics and space sciences has pushed Canada out of its previously strong position in geophysics.

In Applied Mathematics and Computer Science (R.F.14:47) as in Main Mathematics, we had a single excellent paper, also from the west, this time the University of Victoria: I. Barrodale, F.D.K. Roberts ("Solution of an Overdetermined System of Equations in the l_1 Norm (F4)", **Communications ACM**, 1974, 17:6). In computer science, the usual assumption has been that MIT, Stanford, Toronto, Case and Waterloo dominate the world, roughly in that order. But aside from the excellent paper from Victoria, it may be noted that Anthony N. Michel from the state University at Ames, Iowa was involved in the authorship of three of the top six papers in this group. The top paper, "Input-Output Stability of Composite Feedback Systems 2" (M. Araki, **IEEE Transactions on Automatic Control**, April 1976), was produced at Kyoto University in Japan.

Chapter 4

SUMMARY

This report describes the three main results of a study in bibliometrics involving an evaluation of the research papers and journals monitored by the ISI:

- . the development of a new measure of the quality of research in science and technology;
- . the development of a procedure for using that measure, called relevance, to perform a structural analysis and evaluation of research literature; and
- . the implementation of the procedure using data from the information systems of the ISI with the results of a pilot-study of the implementation of these procedures.

The analysis of the system of journals resulted in a series of controlled classes of journals (i.e., research fronts) for which a number of bibliometric indicators could be tallied. Publication trends, for example, in terms of national shares of output in key areas, were presented. Co-authorship trends between countries and sectors were also investigated. Measures of the dispersion of publishing activities among countries and laboratories are to be contrasted with the high concentration of excellent papers in relatively few laboratories and institutions.

In some few areas such as Solid State Physics (R.F.3:10) one can find an impressive range of Canadian laboratories from all sectors contributing excellent papers. In virtually all areas, isolated individuals can be identified within the higher percentile of relevance in their respective communities. But it could hardly escape one's notice that the overall performance of Canadian laboratories is disappointing in many critical areas. These results are symptomatic, and would have to be related to many factors in order to discover their full implications.

Clearly, the context of the historical evolution of our research institutions, still very much in process, is most relevant. Some of this context can be identified: the mechanisms of the expansion of activities within universities; the orientation and management of government facilities; the emergent and isolated character of industrial research; the difficulties of the linkage among institutions; the inertia of evaluation panels and networks in the system of direct funding; instrumentation; information support; and journals. The quality of output from research activities is clearly not a simple function of size or funds. These are some of the intervening variables in the search for excellence. Without exception, they involve the difficult but historically creative processes of institution building, and we know that these processes were delayed in Canada by our neo-colonial attitude to the much more highly developed institutions in Britain and the United States. Critical studies in the institutional development of our research infrastructure are by now long overdue.

REFERENCES

- [1] The analysis of journal clusters was described fully in an unpublished report to the Science Council, MacAulay, "Research in Canada: An Information Theoretic Investigation" (Ottawa, 1981); dynamics is considered in MacAulay, "Measuring the Quality of Papers and the Dynamics of Fields", **Proceedings, Society for the Social Studies of Science** (Atlanta, 1981) and "The Measured Pace of Paradigmatic Change", Carleton Papers on Post Positive Social Science (Carleton University, Ottawa, 1981).
- [2] Peer evaluation evolved on several fronts, sometimes resembling a commission of enquiry for priority disputes, as when Newton attempted to establish his claim against Leibniz to the discovery of the calculus. Further strains on the institution were introduced when the Royal Society of London began in 1849 to use peer evaluation for the distribution of government funds for science.
- [3] A political theory of intellectual property would be helpful in separating out some of the ideological aspects of this essentially laissez-faire view of the scientific community. Plausible arguments have been made on both sides of this view, some of them may be found in Michael Polanyi, **Personal Knowledge**, University of Chicago Press (Chicago, 1958) and Edward Shils (ed.), **Criteria for Scientific Development: Public Policy and National Goals**, MIT Press (Cambridge, 1968).
- [4] Dugald MacFadyen, "Concordance", **The Encyclopedia Britannica**, 11th ed., Vol. 6, Cambridge University Press (Cambridge, 1910), p. 831. The staff employed by Cardinal Hugh was somewhat larger than that of the Institute for Scientific Information, which makes a concordance of cited first authors in current journals. The latter also have the use of a large scale computer.
- [5] George K. Zipf, **Human Behaviour and the Principle of Least Effort**, Addison-Wesley (New York, 1949), Chapter 2; Charles Osgood, Thomas Sebeok (eds.), **Psycholinguistics: A Survey of Theory and Research Problems**, Indiana University Press (Bloomington, 1967).
- [6] A.J. Lotka, "The Frequency Distribution of Scientific Productivity", **Journal of the Washington Academy of Sciences**, 16 (1926), p. 317; S.C. Bradford, "Sources of Information on Specific Subjects" (1934), reprinted in Bradford, **Documentation**, Crosby, Lockwood (London, 1948). The mathematical foundation is discussed in Robert Fairthorne, "Empirical Hyperbolic Distributions (Bradford-Zipf-Mandelbrot) for Bibliometric Description and Prediction", **Journal of Documentation**, 25, 4 (Dec. 1969). The subject is discussed currently in most issues of **Scientometrics**.
- [7] William Goffman, Kenneth Warren, "A Mathematical Analysis of a Medical Literature: Schistosomiasis 1852-1962", Robert Cheshier (ed.), **Information in the Health Sciences**, Cleveland Medical Library Association (Cleveland, 1972), Chapter 17; Goffman, "Mathematical Approach to the Spread of Scientific Ideas: The History of Mast Cell Research", **Nature**, 212:5061 (Oct. 29, 1966), p. 449.
- [8] Attempts have been made to discover the prevalence of various types of citations. M.J. Moravcsik, P. Murugesan, "Some Results on the Function and Quality of Citations", **Social Studies of Science**, 5 (1975), p. 86; D.E. Chubin, S.D. Moitra, "Content Analysis of References: Adjunct or Alternative to Citation Counting?", **ibid.**, p. 425. A different approach is taken in H.G. Small, "Cited Documents as Concept Symbols", **ibid.** (1978), p. 327 and G.N. Gilbert, "Referencing as Persuasion", **ibid.** (1977), p. 113. The result of these and several current "micro-sociological" studies of publication and referencing behaviour is, among other things, to cast doubt on the simplistic but widely-held assumptions that publication is a communicative act and referencing an indicator of the flow of information.
- [9] Henry Small, Belver Griffith, "The Structure of Scientific Literatures: Identifying and Graphing Specialties", **Science Studies**, 4 (1974), p. 17.
- [10] Alan Cartter, **An Assessment of Quality in Graduate Education**, American Council on Education (Washington, 1966); Kenneth Roose, Charles Anderson, **A Rating of Graduate Programs**, American Council on Education (Washington, 1970); the Cartter assessment involved a stratified selection of some 4,000 peers, and the Roose-Anderson questionnaires involved 6,000 evaluators in a wider

study. A review of studies which chart bibliometric correlations with these and other non-bibliometric evaluations of research was provided in an important study by Francis Narin, **Evaluative Bibliometrics: The Use of Publication and Citation Analysis in the Evaluation of Scientific Activity**, Computer Horizons and National Science Foundation (Washington, 1976), Chapter 5.

- [11] Narin, *ibid.*, pp. 82 and 83.
- [12] Eugene Garfield, "Citation Analysis as a Tool in Journal Evaluation", *Science*, 178 (Nov. 3, 1972), p. 471, and *ibid.*, Chapter 8.
- [13] Narin, *op. cit.*, p. 313.
- [14] Henry Small, "Co-Citation in the Scientific Literature: A New Measure of the Relationship Between Two Documents", *Journal of the American Society for Information Science* (July/Aug. 1973), p. 265.
- [15] Co-citations generally use the following procedure. Given a file of citations to i and another of citations to j (the cited items may be papers, authors, institutions, journals or other source items and their citation files i and j), the co-citations on ij are given by $i \cap j$. This set intersection is usually normalized by all cites to i and j (thus $i \cap j / i \cup j$) or just by the sum of all cites in the cluster or sample. Such a measure would not be generalizable beyond small samples, and it suppresses the direction of influence among source elements.
- [16] M.M. Kessler, "Bibliographic Coupling Between Scientific Papers", *American Documentation* (Jan. 1963), p. 10. His other papers on the subject date from 1961.
- [17] Derek J. de Solla Price, "Networks of Scientific Papers", *Science*, 149 (July 30, 1965), p. 510.
- [18] The content analysis of abstracts has not proceeded as rapidly as that for citations. An early study is Harold Berko, Seymour Chatman, "Criteria for Acceptable Abstracts: A Survey of Abstracters' Instructions", *American Documentation*, 14:2 (April 1963).
- [19] P. Brown, G.B. Stratton (eds.), *World List of Scientific Periodicals Published in the Years 1900-1960*, 4th ed., Butterworths (Washington, 1963-65).
- [20] C.M. Gottshalk, W.F. Desmond, "Worldwide Census of the Scientific and Technical Serials", *American Documentation*, 14:3 (July 1963), p. 188; K.P. Barr, "Estimates of the Number of Currently Available Scientific and Technical Periodicals", *Journal of Documentation*, 23:2 (1967), p. 110. A surprising 40% mortality level for serials has been arrived at independently in a check by Gottshalk and Desmond at the Library of Congress, and by K.P. Barr, in a more exhaustive analysis of records at the British National Lending Library.
- [21] M. Carpenter, F. Narin, "The Subject Composition of the World's Scientific Journals", *Scientometrics*, 2:1 (1980), p. 53.
- [22] Estimates by Derek Price had set the doubling rate at various points from seven to 15 years, depending on the source of journal counts. D.J. de Solla Price, "Measuring the Size of Science", reprinted in *Who is Publishing in Science*, ISI (Philadelphia), various years.
- [23] E. Garfield, *Current Contents*, 34, Aug. 20, 1979.
- [24] Manfred Kochen, *Cognitive Mechanisms*, IBM (Yorktown Heights, 1960); Kochen, "Stability in the Growth of Knowledge", *American Documentation*, 20:3 (July 1969); C. West Churchman, *The Design of Inquiring Systems*, Basic Books (New York, 1971). A more recent reference is Kochen, "Models of Scientific Output" in Y. Elkana et al. (eds.), *Toward a Metric of Science*, Wiley (New York, 1978), p. 97.
- [25] A good summary of the theory is William Goffman, "A General Theory of Communication", Tefko Saracevic (ed.), *Introduction to Information Science*, p. 726.
- [26] See Appendix I. The analysis of relevance in the sense used here was initially developed by the author for a project in the Complex Systems Institute at Case Western Reserve University (the Information Utility Project, Jan. 1973). Preliminary applications used closure in a distance matrix to partition the source, reported in MacAulay, "Analyzing Formal Sources in a Complex Information Utility", *American Society for Information Science, Proceedings* (Atlanta, 1974); an application to a university faculty is in MacAulay, *The Communications Analysis of a Knowledge Community*, Ph.D. Dissertation, C.W.R.U. (Cleveland, 1976). The large-scale application reported

here was developed as a pilot project in Science Indicators for the Science Council of Canada, and reported initially in MacAulay, "A Family of Research Indicators Derived from a Bibliometric Analysis", **Proceedings, Science and Technology Indicators Conference, OECD (Paris, 1980)**.

- [27] An application in *ibid.* (MacAulay, 1974), involved only some 35 biomedical engineering staff; using a similar strategy, Computer Horizons clustered some 103 physics journals (**Evaluative Bibliometrics, op. cit.**, p. 206); an efficient algorithm such as the one used in this study runs into theoretical limits on present computers at about 20,000, which is excellent for journals, but still far too small for the direct analysis of papers.
- [28] Eugene Garfield computed his impact factor for Canadian journals in 1977 **Current Contents**, 33 (Aug. 13, 1979). For example, the **Canadian Journal of Chemistry** ranked number 70 on his list in terms of total citations, but was demoted to number 494 in terms of impact (behind **Canadian Journal of Biochemistry**, only 311th in citations, but 412th in impact). The impact factor is seriously biased because it misses such other factors as the type of papers in the journal (review papers, or letters), their transdisciplinary content (e.g., influencing fields with high citation characteristics), the fact that all citing journals are not the same quality, and the excessively incestuous citation behaviour within mainstream countries like the U.S. In general, such a measure takes seriously the idea of measuring a flow of information rather than looking at resultant relations of influence. Citations alone can mean many things in addition to a flow of information. Nevertheless, in its policy paper on Canadian journals, a committee of the Royal Society used these data directly as a measure of quality (**The Press of Knowledge**, Royal Society (Ottawa, 1978)). More recently, the Bovey Commission on the universities of Ontario committed itself to a similarly indefensible measure.
- [29] The data base separates addresses in Scotland and Wales from England, as for Soviet republics, and since Scottish research as distributed among journal clusters, represents a very different profile from that in England, it is useful to retain the separation.
- [30] The industrial share was down from 11% in 1973, and for a very general eight-field allocation of journals, U.S. industry produced 36% of papers in engineering and technology (National Science Board, **Science Indicators - 1980** (Washington, 1981), p. 251). The U.S. dictionary does not cover small laboratories producing fewer than 10 papers/year; therefore these data understate the industrial comparison.
- [31] The institutionalization of inter-sectoral research activities, with special reference to pilot plant facilities involving university, industry and government, was examined in **Machine in the Garden**, Discussion paper, J. MacAulay and P. Dufour, Science Council of Canada, 1984.
- [32] The "currency" or "vintage" in the use of the past years of a literature can be used as an accurate overall indicator of its dynamics. Dr. Lam derived a measure for the contribution of year i to any particular vintage: $V_i = (\% \text{ of all 1978 cites attributed to year } i) \times (1979 - \text{year } i)$;

and thus the vintage character of the k th journal front is
$$V_k = \sum_{i=1}^n v_i$$

for n cited years of literature. The cited year column is the only aspect of the cited body of science which can now be read in its entirety. Thus, while the vintage measure may have some peripheral interest to historians, it is actually the most critical measure available to confirm the boundaries of research areas.

- [33] There is a slight time lag for inclusion of papers in the ISI "year", and this introduces a bias against distant and foreign publications. That is, some 1976 papers would actually be in 1977 tapes, and more of these would be expected from abroad. We found addresses for 317,895 of the 391,479 relevant papers. Searching for addresses after doing the journal and paper evaluations greatly reduces the complexity of location dictionaries. This is what we refer to as a "journal-driven" strategy.
- [34] One can examine some of the available assumptions in Jonathan Cole, Stephen Cole, **Social Stratification in Science**, University of Chicago Press (Chicago, 1973), Chapter 8.
- [35] J. Hughes, "Isolation of an Endogenous Compound from Brain with Pharmacological Properties Similar to Morphine", **Brain Research**, 88:2 (1975), p. 295.
- [36] L.P. Renaud, J.B. Martin, P. Brazeau, "Depressant action of TRH, LH-RH and Somatostatin on Activity of Central Neurons", **Nature**, 255 (May 15, 1975), p. 233.

- [37] "Immunoreactive LH-RH Neurons on the Hypothalamus Identified by Light and Fluorescent Microscopy", **Cell and Tissue Research**, 157 (1975), p. 423, by D.V. Naik, Dept. of Anatomy, Sherbrooke; the MRC group at Laval produced No. 11: (Cell Tiss. Re. 161 (1975), p. 385), along with two endocrinologists from Tulane.
- [38] In view of this problem, a more reasonable basis of comparison among organizations might be to simply compare their rank in the top percentile and their rank in the top decile.
- [39] Y.K. Chau, P.T.S. Wong, H. Saitoh, "Determination of Tetraalkyl Lead Compounds in the Atmosphere", **Journal of Chromatographic Science** (1976), 14, p. 162.

Appendix I

BIBLIOMETRICS: HISTORIC PERSPECTIVE

Like fresh air and sunshine, knowledge is a public good in which the property, though valuable, cannot be privately appropriated. Nevertheless, to become a public possession, knowledge, both new and old, must be coded in some form by which information about an investigator's understanding of some aspect of nature can be circulated and retrieved. For this reason alone, science is, at least in principle, open to formal analysis. In practice, we do not yet know how to analyse the subtle coding devices which theories and paradigms seem to be, nor even to come to terms with the means by which such contextual elements as tacit skills are transmitted from innovative investigators to their apprentices. But because discursive knowledge, which appears as a non-appropriable public good, is central to the whole enterprise, priority in new discoveries must be established by public recognition; and thus formal accounts are circulated in a public way.

Historians have frequently noted that many of the innovations important to European science took place in the seventeenth century. A number of scientific societies were formed at that time, along with the first national laboratories, to say nothing of the most fundamental contributions to physics and mathematics. But important changes took place as well in the means for circulating information about those discoveries. The meetings of the societies were important in this respect, and indeed this was essentially the purpose of the "invisible college", by which Robert Boyle referred to the informal meetings which led to founding the Royal Society of London. But lectures and demonstrations had been used as far back as Archimedes (along with the publication of scientific treatises), and universities from medieval times had preserved and greatly extended this practice. The innovation of lasting significance was a transformation in the means of communicating discoveries: from the private circulation of scientific correspondence to its formal publication in journals.

For transformations on the scale permitted by this innovation, sociologists reserve the terms "gemeinschaft-gesellschaft", an argot of untranslatable majesty. But, as with other social transformations due to changes in communications, social and normative factors turn out to be at least as important as the more visible technical developments.

Private networks of investigators had previously been keeping in touch through what now seems a very extensive practice of writing letters. The latter often contained detailed accounts of discoveries, sometimes using a cipher or secrecy code, mixed in with personal speculations and diverse ideas in alchemy and philosophy. Given the extreme political and religious turmoil of the seventeenth century, these networks were surprisingly cosmopolitan. On an informal basis, Father P. Marin Mersenne enormously improved the range and effectiveness of this process by re-circulating the correspondence from his wide range of contacts to the others in his network. Indeed, Mersenne was instrumental in circulating the work of Descartes, Pascal and Galileo, among many others.

The scientific societies helped to institutionalize and formalize this process. Perhaps the earliest society was the "Accademia del Lincei", established in Rome, 1603, with Galileo among its distinguished members. Its Florentine successor, the "Accademia del Cimento", devoted itself more directly to experiments, publishing a collection of them in 1667 (though the exercise was not repeated on a regular basis). Rather informal scientific societies like these proliferated in Europe, eventually attaining at least nominal royal patronage in the Restoration England of 1662, and substantially so in France in 1666, where something like a national laboratory was established.

The first scientific journals came out in 1665. The "Journal des Scavans", edited in Paris by Denis de Sallo, appeared weekly with current news of experiments, books and technical inventions, and opinion on many controversial subjects, not only in natural philosophy, but including law, religion and the arts. Perhaps it's not surprising that the journal was frequently suppressed.⁽¹⁾ This experience informed the British, who were able to establish a more durable instrument.

The Royal Society of London exercised a great portion of political realism in its constitution and activities, surviving as it did, both civil and religious wars, incorporating all sides and offending none with a program that Robert Hooke described as follows:

"The Business and Design of the Royal Society is: To improve the knowledge of natural things, and all useful Arts, Manufactures, Mechanics, Practices, Engynes and Inventions by Experiments (not meddling with Divinity Metaphysics, Moralls, Politicks, Grammar, Rhetoric, or Logick)."⁽²⁾

See footnote(s) at end of Appendix I.

Their first Royal Charter (1662) accordingly granted "the full power and authority...to print such things, matters and businesses, concerning the said Society", and also "to hold Correspondence and Intelligence with any Strangers, whether Private Persons, or Collegiate Societies or Corporations, without any Interruption or Molestation whatsoever".(3) In due course, the "Philosophical Transactions" of the Royal Society began appearing on a monthly basis in March, 1665, by and large excluding all matters not strictly considered scientific by the Society and its secretaries.(4)

Henry Oldenburg was appointed the first corresponding secretary of the Society. A German expatriate who had studied at Oxford, he acted for many years as consul in England for Lower Saxony. As secretary, he developed an extensive range of correspondents throughout Europe. The difference of this from the Mersenne network was that a "letter" to Oldenburg was recorded at the Society, and became a somewhat more formal statement of the nature, timing and ownership of discoveries. Priority disputes were frequent then as now, and this represented an opportunity to quickly establish priority without producing a lengthy treatise.

The Society could repay the labours of its two secretaries with some honour, but no money (reflecting its own relationship with Charles II, who became a member, but was never a great benefactor). Therefore, as a private venture, but with the approval of the Society, Oldenburg began publishing the "Transactions" in London, 1665. It provided a small income for himself, and for his readers: accounts of experiments performed before the Society, articles, and "letters" from correspondents on scientific matters, edited, of course, by Oldenburg. The Fellows of the Society, which included many foreign scientists, thereby acquired a direct means for the publication of accounts of their original work. Of course, many non-members were within Oldenburg's network of correspondents, and indeed, this seems to have been an important device for recruitment to the Society as well.(5)

Oldenburg's creative work in institutionalizing the system of scientific correspondence brought him little financial return (indeed his independence and zest for foreign correspondence landed him in the Tower of London for two months),(6) and the Transactions survived until the present time, despite the efforts of his rival and successor, Robert Hooke, who temporarily managed to suppress publication. The journal allowed very large and impersonal markets in intellectual property to develop. Without knowing his readers, an investigator could place his intellectual property in the public domain, in exchange for which he might expect to be accorded public recognition of his priority of discovery. The letter and the paper, which have evolved much over the years into a highly formalized style, complete with references and proper acknowledgements of intellectual debts, could easily, and indeed in this century, have largely been replaced by more effective means of communication. But they endure and have increased their importance commensurate with the size of research communities because they are really pronouncements, or claims, quite as much as they were ever merely informative.

In his study of priority disputes, R.K. Merton discerned the normative, constraining and highly moralistic behaviour surrounding the exchange and correct acknowledgement of intellectual property. Pushed into the extreme, this excessively individualist form of market competition can become "dysfunctional", one of the bad things in Merton's lexicon:

"It can lead scientists to develop an extreme concern with recognition which is in turn the validation by peers of the worth of their work. Contentiousness, self-assertive claims, secretiveness lest one be forestalled, reporting only the data that support a hypothesis, false charges of plagiarism, even the occasional theft of ideas and, in rare cases, the fabrication of data, - all these have appeared in the history of science and can be thought of as deviant behavior in response to a discrepancy between the enormous emphasis in the culture of science upon original discovery and the actual difficulty many scientists experience in making an original discovery."(7)

Thus, the paper became the chief instrument for making priority claims in intellectual property, and having these claims evaluated by peers (see Reference 2). This meant initial refereeing at the level of editorial acceptance, but ultimately, the response to a paper is given by the scientific community at large. In that forum, the ultimate value of a contribution is just the influence or importance it acquires with respect to the work of others in all research communities. Accordingly, recognition in terms of actual use may be delayed precisely because information is not free. It is obviously costly to produce and circulate, but more fundamentally, information is intellectually costly to consume, and directly so in proportion to its originality and novelty from the user's point of view.

See footnote(s) at end of Appendix I.

Footnotes

- (1) Some 111 volumes were published from 1665-1792, when the Journal was suppressed, along with other institutions and eminent scientists, during the French Revolution. Douglas McKie, "The Scientific Periodical from 1665 to 1798", Allan Ferguson (ed.), **Natural Philosophy Through the 18th Century and Allied Topics**, Taylor, Francis (London, 1948), p. 122.
- (2) Robert Hooke (1663), quoted in Wolfgang van den Daele, "The Social Construction of Science", E. Mendelsohn, P. Weingart, R. Whitley (eds.), **The Social Production of Scientific Knowledge**, Reidel (Dordrecht, 1977), p. 31.
- (3) Quoted in *ibid.*, p. 29.
- (4) R.K. Merton, ("Changing Foci of Interests in the Sciences and Technology" (1938), in Robert Merton, **The Sociology of Science**, University of Chicago Press (Chicago, 1973), Chap. 8), was the first to study the content of the early "Transactions".
- (5) This point is advanced in L. Mulligan, G. Mulligan, "Reconstructing Restoration Science: Styles of Leadership and Social Composition of the Early Royal Society", **Social Studies of Science**, 11 (1981), p. 327. A somewhat contrary view is in M. Hunter, "Reconstructing Restoration Science: Problems and Pitfalls in Institutional History", **Social Studies of Science**, 12 (1982), p. 451, emphasizing the role of others in recruitment.
- (6) The warrant issued for his arrest (June 20, 1667) referred to "dangerous designs and practices". Pepys, the Walter Winchell of his time, thought this meant foreign correspondence. For a more thoughtful analysis, see Douglas McKie, "The Arrest and Imprisonment of Henry Oldenburg", **Notes and Records of the Royal Society**, 6 (1949), p. 28. His correspondence has now been collected: A.R. Hall, M.B. Hall (eds.), **The Correspondence of Henry Oldenburg**, six volumes, University of Wisconsin Press (Madison, 1965-1976).
- (7) R.K. Merton, "Priorities in Scientific Discoveries" (1957), reprinted in Merton, **The Sociology of Science**, (op. cit.), p. 323. He elsewhere gave to this opiate of the intellectuals a more personal motivation, "insanabile scribendi cacoethes", the itch to publish. Robert Merton, **On the Shoulders of Giants: A Shandean Postscript**, Harcourt, Brace (New York, 1965), p. 83.

Appendix II

THE ANALYSIS OF RELEVANCE

In this study relevance is taken to be a relation among the objects which define an information source under given conditions of inquiry. From the point of view of an inquiring user, the relevance of a document depends on one's changing state of knowledge. That is, a given document may or may not be relevant, depending on where one is presently inquiring in the source. Given conditions of repeated inquiry, William Goffman pointed out(1) that a matrix of transition probabilities could be computed which would in effect, represent the transitivity relations or paths traced out on a source by inquiring users.

In a source S consisting of n objects, which may be a set of documents, a vocabulary, a community of authors, etc., we may represent the usage of any information conveying object in the source as U_i . For example, this could be the file of all articles that cite the source object S_i in a time period, and this would represent a particular evaluative usage. Thus, if a user is inquiring at S_i , the probability of his inquiring at S_j is the common usage (or intersection of U_i and U_j) over the usage of S_i . In other words, the propensity of S_i users to inquire at S_j is:

$$P_{ij} = (U_i \cap U_j) / U_i \quad (1)$$

By measuring the probability that S_j will be found useful to inquirers given the condition that S_i was also useful, Goffman was able to retain the subtlety of time dependency and learning in his indirect method of information retrieval.

We here interpret the transition probability as a marginal propensity to inquire, and as such it is indirectly an estimate of the cost of inquiry, which we began to introduce at the conclusion of Appendix I. If a high proportion of S_i users proceed to S_j , the cost must be minimal. This means not only that the two source objects may be associated together in terms of intellectual distance, but that a direction may be attached to the ordering relation of influence or relevance among source objects. This is typically not a symmetric relation, and would only become so if the files U_i and U_j were identical. (Symmetry in this relation is one of the unwarranted assumptions in a co-citationist approach.)

While the transition probability overcomes many practical problems in the use of citations, and appears to accurately reflect the relations of influence among source objects, it suppresses the relative importance of various linkages in the graph. This aspect of source usage may be re-introduced by means of Shannon's statistical measure of the contribution of each element of a source to the degree of organization of the whole source. The Bradford-Zipf curves in fact demonstrate such a "Matthew effect" over the whole source (R.K. Merton's term, but he failed to codify it); Shannon's entropy measure correctly builds up this effect from its constituent elements.

Thus the relative importance of any of the $n(n-1)$ ordered pairs in a source of n information conveying objects is obtained from the statistical entropy of each pair in turn:

$$e_{ij} = - P_{ij} \ln P_{ij} \quad (2)$$

Where P_{ij} is the probability of all common usage in the source being focussed on the linkage of S_i and S_j :

$$P_{ij} = (U_i \cap U_j) / \sum_{i,j=1}^n (U_i \cap U_j) \quad (3)$$

where $\sum_{i,j=1}^n P_{ij} = 1$ and $P_{ij} = P_{ji}$. Symmetry in this case prevails.

See footnote(s) at end of Appendix II.

For some purposes in studying the dynamics of research specialties, it will be useful to compute the entropy of a source S , consisting of n information conveying objects:

$$H_S = \sum_{i,j=1}^n e_{ij} \quad (4)$$

The two probability measures may be combined as a measure of the relevance on an ordered pair of source objects, or more specifically, its marginal relevance under given conditions of inquiry:

$$r_{ij} = (e_{ij}^{\wedge}) (p_{ij}) \quad (5)$$

$$\text{and } r_j = \sum_{i=1}^n r_{ij} \quad (6)$$

$$\text{and } R_S = \sum_{i,j=1}^n r_{ij} \quad (7)$$

Footnote

- (1) William Goffman, "An Indirect Method of Information Retrieval", *Information Storage and Retrieval*, 4:4 (Dec. 1968), collected in Saracevic, *ibid.*, p. 485.

Appendix III

IMPLEMENTATION PROCEDURE

The relations of relevance among source objects have certain mathematical properties which are useful for the purpose of analysing the structure of large and heterogeneous information sources. Again, following Goffman's "indirect method" (see Reference 25 and Appendix II, footnote 1), we design an algorithm which can read in ordered pairs of source objects incrementally from greatest to least relevance. Each of the $n(n-1)$ ordered pairs is a possible arc or edge from one vertex to another in a directed graph of source objects. Each single vertex represents an information conveying object in the source. Each object is at least minimally relevant to itself ($P_{ii} = 1$), and this is a reflexive relation which Goffman called **conversance**.

A sequence of arcs from one vertex to a final vertex, with no repeated vertices, defines a **communication path** on the source, with both reflexive and transitive properties. These paths through the source represent a "unilateral connection" or a partial ordering of the source. Thus, an object S_j will have an antecedent set, which is its range of influence.

As the algorithm traces out these collective footprints through the source, it also observes another mathematical relation, this time with symmetric properties. When at least one path exists from a vertex i to another k , and at least one path exists from k back to i , we have an **intercommunication path**, or closed walk; this is an equivalence relation with reflexive, transitive and symmetric properties. It therefore provides for a partition of the source into disjoint equivalence classes. A maximal set of objects with this property is an intercommunication cluster which we define as a "research front" of source objects.

Because any data source will exhibit more or less seriously uneven disciplinary and geographical coverage of the system of journals, and because the publication rates vary among research fields whether or not they are well represented, it is necessary to build into the algorithm a relevance threshold that will be sensitive to these characteristics as they may vary from one cluster to another. (Other things being equal, the investigator may want to obtain a weak covering which would be a graph of the central core of a research front.) The depth first searching algorithm described below reads the relevance on arcs ordered incrementally, and at any given point a number of clusters are growing simultaneously. When the marginal relevance on an arc fails to augment the total relevance in that cluster by more than a threshold percentage (in our analysis of ISI journals, this was set at $r_\alpha = .001$), that equivalence class or cluster is considered to be saturated, its structure is recorded, and it is then collapsed to a single vertex.

Since the threshold is established relative to the strength of relevance relations among objects, the analysis yields classes of weakly connected clusters as it nears the tail of the distribution. This means that new research areas are not screened out of the analysis. The procedure is iterative, and can be repeated using clusters as vertices: this results in an analysis into "fields" of research fronts. However, the main value of the analysis is that it provides an evaluation of source objects in terms of their relevance to other source objects; it clusters those objects into mutually exclusive classes, and it orders those objects and classes into antecedent sets which show their range of influence.

The analysis which has been outlined above would normally be carried out by means of operations which have been developed for sparsely filled matrices. However, an effective implementation need not be carried out by means of traditional techniques of matrix analysis. Indeed an implementation of the size proposed in this study cannot be carried out in this way. Instead, we must specify an approach by which the clustering algorithm can be performed on very large information sources, using present generation computers.

A comprehensive formalism for determining the cost of solving problems has been developed which allows one to select which method among many is most efficient, and thus most appropriate.(1) For any problem, we can associate a **size**, which is the number of characters required to write down the input to an algorithm for its solution. The number of steps used by the algorithm is a function of the **size** of the problem. In general, we give preference to an algorithm whose complexity increases as slowly as possible when the problem size is increased, and the contribution of formal analysis allows us to anticipate these growth rates.

See footnote(s) at end of Appendix III.

A number of clustering algorithms have been discussed in the literature on bibliometrics. Most of these involve the analysis of small samples of literature, where the luxury of direct matrix solutions can be tolerated. We need not attempt to review those solutions here since they increase in complexity too sharply with increases in size, and cannot reasonably be implemented on large sources.

The relative growth rate for the eigenvalue solutions used hitherto in bibliometric clustering problems is in the order of $O(n^3)$ for n journals. For 4,000 ISI journals, this would require 10^5 times as much computation time as the implementation used here. Our goal is to obtain reliable estimates of the computation time required to solve a problem of size n . For an algorithm, we define $S(n)$ to be a function; when evaluated at k , $S(k)$ is the time required by the algorithm to solve an input problem of size k . A brief technical note on this may be helpful (Colbourn, et al.).(2)

Given the function $S(n)$, we would be able to easily decide how much computation time our particular problem would use. Unfortunately, the exact determination of $S(n)$ for most nontrivial algorithms is beyond current techniques. Nonetheless, procedures in algorithm analysis (see Aho, et al., Reference 22), can be used to determine the growth rate of the function $S(n)$.

Along these lines, we say the function $S(n)$ is $O[f(n)]$, ["order $f(n)$ "], if there is an absolute constant c for which $S(n) \leq cf(n)$. By way of example, for $g(n) = 1.5n + 7\log n + 300$, we have $g(n) = O(n)$: in other words, asymptotically, $g(n)$ grows as a linear function of n .

An algorithm is considered efficient if its computation time is $O(n^k)$ for some constant $k > 0$: that is, a polynomial in the size of the input. Similarly, an algorithm operating in $O(n)^k$ time is considered more efficient than one which does not. Intuitively, this notion reflects our preference for an algorithm whose complexity increases as slowly as possible when the size is increased, as opposed to one whose solution operates in $O(n)^3$ time for a set of n journals.

Having formulated the clustering problem in terms of the properties of a digraph, it is possible to program the algorithm to organize research fronts and collapse them to single vertices without increasing the complexity of the operation more rapidly than the size of the problem. R.E. Tarjan has described just such an optimal algorithm for clustering the strongly connected components in a digraph.(3) This approach required only one four-thousandth of the computer time required for the transitive closure solution of ISI journals.

A necessary modification to the Tarjan algorithm involves reading in arcs which have been ranked by the relevance factor. This is to permit the threshold to be established with respect to a given cluster or research front, rather than imposing a single threshold for the whole source. Therefore, our implementation incorporates some techniques proposed by G.A. Cheston for incremental algorithms.(4) Using these techniques, we have analysed the structure of relevance relations in sources ranging up to 20,000 information conveying objects.

See footnote(s) at end of Appendix III.

Footnotes

- (1) A description of this formalism is in A.V. Aho, J.E. Hopcroft, H.D. Ullman, **The design and analysis of computer algorithms** (Addison, Wesley, 1974); a less rigorous presentation is in H.R. Lewis, C.H. Papadimitron, "The Efficiency of Algorithms", **Scientific American**, 238:1 (1978), p. 96.
- (2) The algorithm was outlined in Charles Colbourn, Marlene Colbourn, James MacAulay, "Specification of Research Fronts: Methodology and Algorithms", Conference on Numerical Mathematics and Computing, University of Manitoba (Winnipeg, 1980); and its implications in James MacAulay, "The World Brain Again: This Time with Feeling", World Classification Society, Psychometric Society, Proceedings of a Joint Meeting (Montreal, 1982).
- (3) R.E. Tarjan, "Depth First Search and Linear Graph Algorithms", **SIAM J. Computing** 1:2 (1972), p. 146.
- (4) G.A. Cheston, "Incremental Algorithms in Graph Theory", Ph.D. Dissertation (University of Toronto, 1976). An excellent survey of the field of graph theory and its relevance in many areas of policy research is Fred Roberts, **Graph Theory and Its Application to Problems of Society**, SIAM (Philadelphia, 1978).

Appendix IV

CLASSIFICATION OF RELEVANT JOURNALS

This is a listing of journals in influential research fronts obtained from an analysis of the **Journal Citation Reports** for 1977. The listing adopts a Field: Front notation sequence, giving journal fronts in the order in which they saturated, which would also be the order of their strength of intra-connectedness and the order of their overall importance in the whole system. Therefore, more attention should be paid to the performance of laboratories in journal classes that occur early in the sequence. They represent the mainstream of world research.

The journal fronts can be resorted into fields by means of the Front to Field concordance listed below. Journals within each group are then listed in order of their immediate relevance in the system of ISI journals, and their percentage shares of the relevance of all journals in each front is given as well. Percentage shares may occasionally sum to more than 100 due to the fact that a few JCR journals or other serials, marked with an asterisk (*), were found to be significant members of these groups but were not found on the correction tapes for 1978; i.e., they are not used in other ISI products such as the Science Citation Index, which are generated in the 11-character format from the correction tapes.

For each journal in this listing, the full name is given, along with the founding year and city of publication, as far as these could be determined from reference in **Ulrich's International Periodicals Directory**, the holdings of CISTI and the libraries of the Department of Health and Welfare. No cross-checks were run on these and, of course many, cities are simply the mailing points for journals which are essentially international in character. A single letter code identifies the languages in which papers and abstracts are published. Journal fronts with very few journals or little Canadian participation, and one or two for which details were not readily at hand are listed here in 20-character short-form only.

Field Front Concordance

Front	Field	Front	Field	Front	Field
1	1	30	6	59	17
2	1	31	9	60	25
3	4	32	2	61	10
4	3	33	16	62	27
5	1	34	7	63	10
6	1	35	15	64	28
7	1	36	2	65	20
8	1	37	13	66	18
9	3	38	10	67	21
10	3	39	2	68	22
11	5	40	2	69	29
12	2	41	7	70	30
13	8	42	9	71	31
14	3	43	2	72	23
15	2	44	2	73	24
16	12	45	10	74	32
17	6	46	2	75	26
18	11	47	14	76	33
19	2	48	9	77	7
20	5	49	10	78	34
21	2	50	10	79	7
22	13	51	7	80	35
23	9	52	14	81	9
24	2	53	7	82	14
25	5	54	10	83	7
26	2	55	14	84	36
27	2	56	2	85	19
28	10	57	6	Total - 85 fronts 36 fields	
29	5	58	10		

LIST OF JOURNAL GROUPS BY RESEARCH FRONT

Field. Name Front	Field. Name Front
1.1 Core Biochemistry	2.43 Clinical Pharmacology, Geriatrics
1.2 Core Medicine	2.44 Anaesthesiology
4.3 Core Chemistry	10.45 Secondary Psychiatry and Psychology
3.4 Core Physics	2.46 Clinical Medicine, Reproductive Biology
1.5 Pharmacology and Clinical Chemistry	14.47 Applied Mathematics and Computer Science
1.6 Cell Research	9.48 Secondary Geophysics, Atmospheric Sciences
1.7 Gastroenterology, Surgery	10.49 Secondary Plant Biology
1.8 Immunology and Pediatrics	10.50 Applied Statistics, Population Biology
3.9 Chemical Physics	7.51 Secondary Chemical Engineering
3.10 Solid State Physics	14.52 Secondary Law Group 2
5.11 Plant Biology	7.53 Secondary Applied Physics
2.12 Secondary Biochemistry	10.54 Marine Biology
8.13 Geology and Astrophysics	14.55 Applied Economics
3.14 Pharmacology	2.56 Biomedical Engineering, Respiratory Diseases
2.15 Microbiology and Macromolecular Science	6.57 Speech and Hearing
12.16 Main Law	10.58 peripheral
6.17 Main Mathematics	17.59 peripheral
11.18 Neurosurgery	25.60 peripheral
2.19 Nutrition, Clinical Medicine and Public Health	10.61 Entomology
5.20 Physical Chemistry	27.62 peripheral
2.21 Ecology	10.63 Horticulture
13.22 Ophthalmology	28.64 peripheral
9.23 Physics of Materials	20.65 Mental Retardation
2.24 Secondary Biochemistry, Human Genetics	18.66 India: Biology
5.25 Physical Chemistry: U.S.S.R.	21.67 Japan: Biomedicine
2.26 Psychiatry, Psychology	22.68 Secondary Veterinary Science
2.27 Immunology and Allergies	29.69 peripheral
10.28 Main Economics	30.70 peripheral
5.29 Plant Biology and Soil Science	31.71 peripheral
6.30 Applied Mathematics, Secondary Physical Applications	23.72 peripheral Biochemistry
9.31 Secondary Geophysics and Space Science	24.73 peripheral
2.32 Secondary Microbiology, Veterinary Science	32.74 peripheral
16.33 Secondary Law	26.75 peripheral
7.34 Chemical Engineering	33.76 peripheral
15.35 Dentistry	7.77 peripheral
2.36 General Clinical Medicine	34.78 peripheral
13.37 Laryngology and Plastic Surgery	7.79 Materials Science, Metallurgy
10.38 Animal Biology	35.80 peripheral
2.39 Applied Microbiology, Biotechnology	9.81 Secondary Geology
2.40 Behavioural Sciences	14.82 Secondary Probability
7.41 Photo-chemistry, Applied Physics	7.83 Russia: Peripheral Chemistry
9.42 Environmental Sciences and Chemical Analysis	36.84 peripheral
	19.85 Textiles

LIST OF JOURNALS IN EACH FRONT

R.F.

Core Biochemistry

- 1:1: 1 NATURE, 1869, London, England, 14.4%, E.
 2 SCIENCE, 1883, Washington, D.C., 13.0%, E.
 3 JOURNAL OF BIOLOGICAL CHEMISTRY, 1905, Bethesda, Md., 12.0%, E.
 4 NATIONAL ACADEMY OF SCIENCES, 1915, Washington, D.C., 10.6%, E.
 5 BIOCHIMICA ET BIOPHYSICA ACTA, 1947, Amsterdam, Netherlands, 10.3%, E.
 6 BIOCHEMICAL JOURNAL, 1906, Colchester, England, 8.2%, E.
 7 BIOCHEMICAL AND BIOPHYSICAL RESEARCH COMMUNICATIONS, 1959, New York, U.S.A., 7.0%, E.
 8 BIOCHEMISTRY (U.S.), 1962, Washington, D.C., 6.5%, E.
 9 ARCHIVES OF BIOCHEMISTRY AND BIOPHYSICS, 1942, New York, U.S.A., 5.6%, E.
 10 EUROPEAN JOURNAL OF BIOCHEMISTRY, 1967, Berlin, West Germany, 4.2%, E, F, G.
 11 JOURNAL OF MOLECULAR BIOLOGY, 1959, London, England and New York, U.S.A., 4.1%, E, F, G.
 12 FEBS LETTERS, 1968, Amsterdam, Netherlands, 4.0%, E, F, G.

Core Medicine

- 1:2: 1 LANCET, 1823, London, England, 7.9%, E.
 2 NEW ENGLAND JOURNAL OF MEDICINE, 1828, 7.4%, E.
 3 JOURNAL OF CLINICAL INVESTIGATION, 1924, New York, U.S.A., 6.7%, E.
 4 ANNALS OF NEW YORK ACADEMY OF SCIENCE, 1977, New York, U.S.A., 6.5%, E.
 5 SOCIETY FOR EXPERIMENTAL BIOLOGY AND MEDICINE, PROCEEDINGS, 1903, New York, U.S.A., 6.0%, E.
 6 FEDERATION PROCEEDINGS, AMERICAN SOCIETY OF EXPERIMENTAL BIOLOGY, 1964, New York, U.S.A., 5.4%, E.
 7 JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION, 1883, Chicago, Ill., 5.1%, E.
 8 BRITISH MEDICAL JOURNAL, 1857, London, England, 5.0%, E.
 9 AMERICAN JOURNAL OF PHYSIOLOGY: HEART AND CIRCULATORY PHYSIOLOGY, 1898, Bethesda, Md., 4.6%, E.
 10 JOURNAL OF EXPERIMENTAL MEDICINE, 1896, New York, U.S.A., 4.0%, E.
 11 ANNALS OF INTERNAL MEDICINE, 1927, Philadelphia, Pa., 3.9%, E.
 12 AMERICAN JOURNAL OF MEDICINE, 1946, New York, U.S.A., 3.9%, E.
 13 JOURNAL OF PHYSIOLOGY, 1878, Cambridge, England, 3.8%, E.
 14 ANALYTICAL BIOCHEMISTRY, 1960, New York, U.S.A., 3.4%, E.
 15 JOURNAL OF IMMUNOLOGY, 1916, Baltimore, U.S.A., 3.2%, E.
 16 ENDOCRINOLOGY, 1917, Baltimore, U.S.A., 3.1%, E.
 17 JOURNAL OF CLINICAL ENDOCRINOLOGY AND METABOLISM, 1941, Baltimore, U.S.A., 3.0%, E.
 18 ARCHIVES OF INTERNAL MEDICINE, 1908, Chicago, Ill., 3.0%, E.
 19 CANCER, 1948, Philadelphia, Pa., 3.0%, E.
 20 CIRCULATION, 1950, Dallas, Texas, 2.7%, E.
 21 CIRCULATION RESEARCH, 1953, Dallas, Texas, 2.5%, E.
 22 METHOD IN ENZYMOLOGY,* 1955, New York, U.S.A., 2.4%, E.
 23 BRAIN RESEARCH, 1966, Amsterdam, Netherlands, 2.3%, E.
 24 AMERICAN JOURNAL OF CARDIOLOGY, 1958, New York, U.S.A., 1.7%, E.
 25 AMERICAN HEART JOURNAL, 1925, St. Louis, Mo., 1.6%, E.

R.F.

Core Chemistry

- 4:3: 1 AMERICAN CHEMICAL SOCIETY JOURNAL, 1879, Washington, D.C., 15.3%, E.
 2 JOURNAL OF CHEMICAL PHYSICS, 1933, New York, U.S.A., 12.3%, E.
 3 JOURNAL OF PHYSICAL CHEMISTRY, 1896, Washington, D.C., 7.8%, E.
 4 JOURNAL OF ORGANIC CHEMISTRY, 1936, Washington, D.C., 6.7%, E.
 5 JOURNAL OF THE CHEMICAL SOCIETY, CHEMICAL COMMUNICATIONS, 1972, London, England, 6.1%, E.
 6 CANADIAN JOURNAL OF CHEMISTRY/JOURNAL CANADIEN DE CHIMIE, 1951, Ottawa, Canada, 6.0%, E, F.
 7 TETRAHEDRON LETTERS, 1959, Oxford, England, 5.8%, E, F, G.
 8 CHEMICAL SOCIETY OF JAPAN, BULLETIN, 1926, Tokyo, Japan, 5.5%, E, F, G.
 9 CHEMISCHE BERICHTE, 1868, Deerfield Beach, Fla. and Weinheim, West Germany, 5.4%, G, summaries in E and G.
 10 ANGELWANDTE CHEMIE, 1888, Deerfield Beach, Fla. and Weinheim, West Germany, 5.0%, G, E.
 11 HELVETICA CHIMICA ACTA, 1918, Basel, Switzerland, 4.7%, G, occasionally E, F and I.
 12 TETRAHEDRON, 1957, Oxford, England, 4.6%, E, F, G.
 13 INORGANIC CHEMISTRY, 1962, Washington, D.C., 4.4%, E.
 14 SOCIETE CHIMIQUE DE FRANCE. BULLETIN, 1858, 3.9%, E.
 15 JUSTUS LIEBIGS ANNALEN DER CHEMIE, 1932, Weinheim, West Germany, 3.6%, G.
 16 JOURNAL OF ORGANOMETALLIC CHEMISTRY, 1963, Lausanne, Switzerland, 3.0%, E, F, G, summaries in E.

Core Physics

- 3:4: 1 PHYSICAL REVIEW LETTERS, 1958, New York, U.S.A., 12.2%, E.
 2 ROYAL SOCIETY OF LONDON, PROCEEDINGS, SERIES A, 1665, London, England, 11.2%, E.
 3 JOURNAL OF APPLIED PHYSICS, 1931, New York, U.S.A., 9.0%, E.
 4 PHYSICAL REVIEW B (CONDENSED MATTER), 1893, New York, U.S.A., 8.6%, E.
 5 PHYSICAL REVIEW A (GENERAL PHYSICS), 1893, New York, U.S.A., 6.4%, E.
 6 PHYSICAL SOCIETY OF JAPAN, JOURNAL/NIHON BUTSURI GAKKAI OJI HOKOKU, 1946, Tokyo, Japan, 5.9%, E, F, G (summaries in E).
 7 REVIEWS OF MODERN PHYSICS, 1929, New York, U.S.A., 5.2%, E.
 8 PHILOSOPHICAL MAGAZINE; A JOURNAL OF THEORETICAL EXPERIMENTAL AND APPLIED PHYSICS OF CONDENSED MATTER, 1768, London, England, 5.2%, E.
 9 PHYSICS LETTERS, SECTION A, GENERAL, ATOMIC AND SOLID STATE PHYSICS, 1962, Amsterdam, Netherlands, 5.2%, E.
 10 SOLID STATE COMMUNICATIONS, 1963, Elmsford, N.Y. and Oxford, England, 4.9%, E.
 11 APPLIED PHYSICS LETTERS, 1962, New York, U.S.A., 4.8%, E.
 12 JOURNAL OF PHYSICS AND CHEMISTRY OF SOLIDS, 1956, Elmsford, N.Y. and Oxford, England, 4.8%, E, F, G.
 13 JOURNAL OF PHYSICS, C: SOLID STATE PHYSICS, 1968, New York, U.S.A., 4.0%, E.
 14 ANNALS OF PHYSICS, 1957, New York, U.S.A., 3.1%, E.
 15 PHYSICS LETTERS, SECTION B: NUCLEAR, ELEMENTARY PARTICLE AND HIGH ENERGY PHYSICS, 1962, Amsterdam, Netherlands, 2.5%, E.

LIST OF JOURNALS IN EACH FRONT - Continued

R.F.

Core Physics - Concluded

- 3:4: 16 PHYSICAL REVIEW, D: PARTICLES AND FIELDS, 1893, New York, U.S.A., 2.4%, E.
 17 NUCLEAR PHYSICS, SECTION A: DEVOTED TO THE EXPERIMENTAL AND THEORETICAL STUDY OF THE FUNDAMENTAL CONSTITUENTS OF MATTER AND THEIR INTERACTIONS, 1967, Amsterdam, Netherlands, 1.9%, E, F, G.
 18 NUCLEAR PHYSICS, SECTION B, 1967, Amsterdam, Netherlands, 1.5%, E.
 19 PHYSICAL REVIEW C: NUCLEAR PHYSICS, 1893, New York, U.S.A., 1.3%, E.

Pharmacology and Clinical Chemistry

- 1:5: 1 JOURNAL OF LABORATORY AND CLINICAL MEDICINE, 1915, St. Louis, U.S.A., 6.8%, E.
 2 EXPERIENTIA: MONTHLY JOURNAL OF PURE AND APPLIED SCIENCE, 1945, Basel, Switzerland, 6.2%, E, F, G, I.
 3 JOURNAL OF PHARMACOLOGY AND EXPERIMENTAL THERAPEUTICS, 1909, Baltimore, U.S.A., 5.3%, E.
 4 AMERICAN JOURNAL OF PATHOLOGY, 1925, Philadelphia, U.S.A., 4.6%, E.
 5 LIFE SCIENCES, 1962, Oxford, England, 4.4%, E, F, G.
 6 BIOCHEMICAL PHARMACOLOGY, 1958, Oxford, England, 4.3%, E.
 7 ACTA PHYSIOLOGICA SCANDINAVICA, 1940, Stockholm, Sweden, 4.1%, E, F, G.
 8 AMERICAN JOURNAL OF CLINICAL PATHOLOGY, 1931, Philadelphia, U.S.A., 3.8%, E.
 9 LABORATORY INVESTIGATION: A JOURNAL OF EXPERIMENTAL METHODS AND PATHOLOGY, 1952, Baltimore, U.S.A., 3.8%, E.
 10 CLINICA CHIMICA ACTA, 1956, Amsterdam, Netherlands, 3.8% E, F, G.
 11 PHYSIOLOGICAL REVIEWS, 1921, Bethesda, Md., 3.7%, E.
 12 BLOOD, 1946, New York, U.S.A., 3.6%, E.
 13 ARCHIVES OF PATHOLOGY AND LABORATORY MEDICINE, 1926, Chicago, Ill., 3.6%, E.
 14 BRITISH JOURNAL OF PHARMACOLOGY, 1946, London, England, 3.5%, E.
 15 CLINICAL RESEARCH, 1953, Thorofare, N.J., 3.4%, E.
 16 JOURNAL OF NEUROCHEMISTRY, 1956, New York, U.S.A., 3.4%, E.
 17 JOURNAL OF GENERAL PHYSIOLOGY, 1918, New York, U.S.A., 3.0%, E.
 18 JOURNAL OF CLINICAL PATHOLOGY, 1947, London, England, 3.0%, E.
 19 CLINICAL SCIENCE AND MOLECULAR MEDICINE, 1955, Baltimore, U.S.A., 3.0%.
 20 JOURNAL OF APPLIED PHYSIOLOGY: RESPIRATORY, ENVIRONMENTAL AND EXERCISE PHYSIOLOGY, 1948, Bethesda, Md., 2.9%, E.
 21 PHARMACOLOGICAL REVIEWS, 1949, Baltimore, U.S.A., 2.7%, E.
 22 BRITISH JOURNAL OF HAEMATOLOGY, 1955, Oxford, England, 2.5%, E.
 23 PFLUEGERS ARCHIV; EUROPEAN JOURNAL OF PHYSIOLOGY, 1868, Berlin, West Germany, 3.3%, mainly E, also F, G.
 24 CLINICAL CHEMISTRY, 1955, Winston-Salem, N.C., 2.3%, E.
 25 EUROPEAN JOURNAL OF PHARMACOLOGY, 1967, Amsterdam, Netherlands, 2.3%, E.
 26 MOLECULAR PHARMACOLOGY, 1965, New York, U.S.A., 2.2%, E.
 27 JOURNAL OF PHARMACY AND PHARMACOLOGY, 1949, London, England, 2.1%, E.
 28 NAUNYN-SCHMIEDEBERG'S ARCHIVES OF PHARMACOLOGY, 1873, New York, U.S.A. and Berlin, Heidelberg, Vienna, 1.9%, E.
 29 ARCHIVES INTERNATIONALES DE PHARMACODYNAMIE ET DE THERAPIE, 1894, Ghent, Belgium, 1.7%, E.

R.F.

Cell Research

- 1:6: 1 JOURNAL OF CELL BIOLOGY, 1955, New York, U.S.A., 9.4%, E.
 2 CANCER RESEARCH, 1941, Baltimore, U.S.A., 7.4%, E.
 3 EXPERIMENTAL CELL RESEARCH, 1950, New York, U.S.A., 6.3%, E.
 4 JOURNAL OF THE NATIONAL CANCER INST., 1940, Bethesda, U.S.A., 6.0%, E.
 5 JOURNAL OF BACTERIOLOGY, 1916, Washington, D.C., 4.8%, E.
 6 JOURNAL OF HISTOCHEMISTRY AND CYTOCHEMISTRY, 1953, New York, U.S.A., 4.0%, E.
 7 ANNUAL REVIEW OF BIOCHEMISTRY, 1932, Palo Alto, U.S.A., 3.9%, E.
 8 JOURNAL OF LIPID RESEARCH, 1959, Bethesda, Md., U.S.A., 3.9%, E.
 9 JOURNAL OF CELLULAR PHYSIOLOGY, 1932, New York, U.S.A., 3.9%, E.
 10 HOPPE-SEYLER'S ZEITSCHRIFT FUER PHYSIOLOGISCHE CHEMIE, 1877, Berlin, West Germany, 3.6%, E, G.
 11 ANATOMICAL RECORD, 1906, New York, U.S.A., 3.6%, E.
 12 VIROLOGY, 1955, New York, U.S.A., 3.4%, E.
 13 JOURNAL OF ULTRASTRUCTURE RESEARCH, 1957, New York, U.S.A., 3.2%, several languages.
 14 COLD SPRING HARBOUR LABORATORY, 1933, Cold Spring Harbour, N.Y., 3.2%, E.
 15 DEVELOPMENTAL BIOLOGY, 1959, New York, U.S.A., 3.0%, E, F, G.
 16 JOURNAL OF VIROLOGY, 1967, Washington, D.C., 2.9%, E.
 17 JOURNAL OF BIOCHEMISTRY, 1922, Tokyo, Japan, 2.8%, E.
 18 INTERNATIONAL JOURNAL OF CANCER, 1966, Geneva, Switzerland, 2.8%, E, F.
 19 AMERICAN JOURNAL OF ANATOMY, 1901, New York, U.S.A., 2.7%, E.
 20 BRITISH JOURNAL OF CANCER, 1947, London, England, 2.5%, E.
 21 JOURNAL OF GENERAL MICROBIOLOGY, 1947, Cambridge, England, 2.5%, E.
 22 CELL, 1974, Cambridge, Mass., 2.4%, E.
 23 JOURNAL OF EXPERIMENTAL ZOOLOGY, 1904, New York, U.S.A., 2.4%, E.
 24 JOURNAL OF ANATOMY, 1866, Cambridge, England, 2.3%, E.
 25 JOURNAL OF COMPARATIVE NEUROLOGY, 1891, New York, U.S.A., 2.0%, E.
 26 EXPERIMENTAL NEUROLOGY, 1959, New York, U.S.A., 2.0%, E.
 27 JOURNAL OF NEUROPHYSIOLOGY, 1938, New York, U.S.A., 2.0%, E.
 28 EXPERIMENTAL BRAIN RESEARCH/EXPERIMENTATION CEREBRALE/EXPERIMENTELLE HIRNFORSCHUNG, 1966, New York, U.S.A., 1.3%, E, F, G.

Gastroenterology, Surgery

- 1:7: 1 GASTROENTEROLOGY, 1943, New York, U.S.A., 11.9%, E.
 2 ANNALS OF SURGERY, 1885, Philadelphia, Pa., 10.3%, E.
 3 SURGERY, GYNECOLOGY & OBSTETRICS (WITH INTERNATIONAL ABSTRACTS OF SURGERY), 1905, Chicago, Ill., 9.4%, E.
 4 SURGERY, 1937, St. Louis, Mo., 9.2%, E.
 5 ARCHIVES OF SURGERY, 1920, Chicago, Ill., 8.4%, E.
 6 RADIOLOGY, 1923, Easton, Pa., 7.4%, E.
 7 AMERICAN JOURNAL OF SURGERY, 1890, New York, U.S.A., 7.3%, E.
 8 AMERICAN JOURNAL OF ROENTGENOLOGY, 1913, Winston-Salem, N.C., 6.5%, E.
 9 GUT, 1960, London, England, 6.2%, E.
 10 BRITISH JOURNAL OF SURGERY, 1913, Bristol, England, 6.0%, E.

LIST OF JOURNALS IN EACH FRONT - Continued

R.F.

Gastroenterology, Surgery - Concluded

- 1:7: 11 JOURNAL OF THORACIC AND CARDIOVASCULAR SURGERY, 1931, St. Louis, Mo., 5.1%, E.
 12 JOURNAL OF UROLOGY, 1917, Baltimore, Md., 4.6%, E.
 13 BRITISH JOURNAL OF RADIOLOGY, 1928, London, England, 4.0%, E.
 14 DIGESTIVE DISEASES AND SCIENCES: FORMERLY AMERICAN JOURNAL OF DIGESTIVE DISEASES, 1934, New York, U.S.A., 3.9%, E.

Immunology and Pediatrics

- 1:8: 1 JOURNAL OF PEDIATRICS, 1932, St. Louis, Mo., 5.2%, E.
 2 PEDIATRICS, 1948, Evanston, Ill., 5.2%, E.
 3 JOURNAL OF INFECTIOUS DISEASES, 1904, Chicago, Ill., 4.3%, E.
 4 AMERICAN JOURNAL OF OBSTETRICS AND GYNECOLOGY, 1920, St. Louis, Mo., 4.2%, E.
 5 SCANDINAVIAN JOURNAL OF CLINICAL & LABORATORY INVESTIGATION, 1949, Oxford, England, 4.1%, E.
 6 ACTA MEDICA SCANDINAVICA, 1919, Stockholm, Sweden, 4.0%, E.
 7 AMERICAN JOURNAL OF DISEASES OF CHILDREN, 1911, Chicago, Ill., 3.9%, E.
 8 AMERICAN JOURNAL OF THE MEDICAL SCIENCES, 1827, Thorofare, N.J., 3.9%, summaries in interlingua.
 9 CLINICAL AND EXPERIMENTAL IMMUNOLOGY, 1966, Oxford, England, 3.8%, E.
 10 CANADIAN MEDICAL ASSOCIATION JOURNAL/ ASSOCIATION MEDICALE CANADIENNE JOURNAL, 1911, Ottawa, Canada, 3.7%, E, F.
 11 ACTA ENDOCRINOLOGICA, 1948, Copenhagen, Denmark, 3.6%, E.
 12 METABOLISM, 1952, Baltimore, U.S.A., 3.6%, E.
 13 DIABETES, 1952, New York, U.S.A., 3.4%, E.
 14 ROYAL SOCIETY OF MEDICINE, PROCEEDINGS, 1907, London, England, 3.4%, E.
 15 JOURNAL OF ENDOCRINOLOGY, 1939, Colchester, England, 3.4%, E.
 16 IMMUNOLOGY, 1958, Oxford, England, 3.2%, E.
 17 MEDICINE, 1922, Baltimore, U.S.A., 3.0%, E.
 18 AMERICAN REVIEW OF RESPIRATORY DISEASE, 1917, New York, U.S.A., 3.0%, E.
 19 INTERNATIONAL ARCHIVES OF ALLERGY AND APPLIED IMMUNOLOGY, 1950, Basel, Switzerland, 2.5%, E.
 20 MAYO CLINIC PROCEEDINGS, 1926, Rochester, Minn., 2.4%, E.
 21 INFECTION AND IMMUNITY, 1970, Washington, D.C., 2.4%, E.
 22 IMMUNOCHEMISTRY, 1964, Elmsford, N.Y. and Oxford, England, 2.4%, E, F, G, SP.
 23 ARCHIVES OF DISEASES IN CHILDHOOD, 1926, London, England, 2.3%, E.
 24 QUARTERLY JOURNAL OF MEDICINE, 1907, London, England, 2.3%, E.
 25 TRANSPLANTATION, 1963, Baltimore, U.S.A., 2.1%, E.
 26 CHEST, 1935, Park Ridge, Ill., 2.1%, E.
 27 CELLULAR IMMUNOLOGY, 1970, New York, U.S.A., 2.0%, E.
 28 ANTIMICROBIAL AGENTS AND CHEMOTHERAPY, 1972, Washington, D.C., 1.9%, E.
 29 BRITISH HEART JOURNAL, 1939, London, England, 1.8%, E.
 30 OBSTETRICS AND GYNECOLOGY, 1953, New York, U.S.A., 1.8%, E.
 31 JOURNAL OF REPRODUCTION AND FERTILITY, 1960, Colchester, England, 1.7%, E.
 32 EUROPEAN JOURNAL OF IMMUNOLOGY, 1971, Weinheim, West Germany and Deerfield Beach, Fla., 1.5%, E.
 33 TRANSPLANTATION PROCEEDINGS, 1969, New York, U.S.A., 1.3%, E.

R.F.

- 1:8: 34 BIOLOGY OF REPRODUCTION, 1969, Champaign, Ill., 0.9%, E.

Chemical Physics

- 3:9: 1 CHEMICAL PHYSICS LETTERS, 1967, Amsterdam, Netherlands, 8.8%, E.
 2 CHEMICAL REVIEWS, 1924, Washington, D.C., 8.2%, E.
 3 ACCOUNTS OF CHEMICAL RESEARCH, 1968, Washington, D.C., 6.1%, E.
 4 ACTA CRYSTALLOGRAPHICA. SECTION B: STRUCTURAL CRYSTALLOGRAPHY AND CRYSTAL CHEMISTRY, 1948, Copenhagen, Denmark, 6.0%, E.
 5 AUSTRALIAN JOURNAL OF CHEMISTRY, 1948, Melbourne, Australia, 5.9%, E.
 6 MOLECULAR PHYSICS, 1958, London, England, 5.5%, E, F, G.
 7 JOURNAL OF INORGANIC AND NUCLEAR CHEMISTRY, 1955, Oxford, England, 5.3%, E.
 8 RECUEIL DES TRAVAUX CHIMIQUES DES PAYS-BAS, 1882, The Hague, Netherlands, 5.0%, E, F, G.
 9 CHEMISTRY AND INDUSTRY, 1923, London, England, 4.8%, E.
 10 ZEITSCHRIFT FUER ANORGANISCHE UND ALLGEMEINE CHEMIE, 1892, Leipzig, East Germany, 4.7%, G.
 11 COLLECTION OF CZECHOSLOVAK CHEMICAL COMMUNICATIONS, 1929, Prague, Czechoslovakia, 4.7%, E, F, G, R.
 12 CHEMICAL SOCIETY, LONDON, PERKIN TRANSACTIONS 2: A JOURNAL OF PHYSICAL ORGANIC CHEMISTRY, 1972, London, England, 4.1%, E.
 13 CHEMICAL SOCIETY, LONDON, JOURNAL: DALTON TRANSACTIONS, A JOURNAL FOR INORGANIC CHEMISTS, 1972, London, England, 4.1%, E.
 14 JOURNAL OF MOLECULAR SPECTROSCOPY, 1957, New York, U.S.A., 3.7%, E.
 15 CHEMICAL SOCIETY, LONDON, JOURNAL: PERKIN TRANSACTIONS 1, ORGANIC AND BIO-ORGANIC CHEMISTRY, 1972, London, England, 3.7%, E.
 16 THEORETICA CHIMICA ACTA/THEORETICAL CHEMISTRY, 1962, Berlin, West Germany, 3.5%, E, F, G, summaries in E.
 17 CHEMICAL AND PHARMACEUTICAL BULLETIN, 1953, Tokyo, Japan, 3.3%, E.
 18 ACTA CRYSTALLOGRAPHICA, SECTION A: CRYSTAL PHYSICS, DIFFRACTION, THEORETICAL AND GENERAL CRYSTALLOGRAPHY, 1948, Copenhagen, Denmark, 2.6%, E.
 19 SYNTHESIS, 1969, Stuttgart, West Germany, 2.4%, E.
 20 INORGANICA CHIMICA ACTA, 1967, Lausanne, Switzerland, 2.1%, E.
 21 INORGANIC AND NUCLEAR CHEMISTRY LETTERS, 1965, Oxford, England, 1.9%, E, G.
 22 COORDINATION CHEMISTRY REVIEWS: AN INTERNATIONAL JOURNAL, 1966, Amsterdam, Netherlands, 1.9%, E, F, G.
 23 CHEMICAL PHYSICS, 1973, Amsterdam, Netherlands, 1.8%, E.

Solid State Physics

- 3:10: 1 ZEITSCHRIFT FUER NATURFORSCHUNG, SECTION A: PHYSICS, PHYSICAL CHEMISTRY, COSMIC PHYSICS, 1946, Tuebingen, West Germany, 6.6%, E, G.
 2 CANADIAN JOURNAL OF PHYSICS/JOURNAL CANADIEN DE PHYSIQUE, 1929, Ottawa, Canada, 6.3%, E, F.
 3 REVIEW OF SCIENTIFIC INSTRUMENTS, 1930, New York, U.S.A., 5.9%, E.
 4 SURFACE SCIENCE, 1964, Amsterdam, Netherlands, 5.3%, E, F, G, summaries in E.
 5 OPTICAL SOCIETY OF AMERICA, JOURNAL, 1917, New York, U.S.A., 5.0%, E.
 6 ELECTROCHEMICAL SOCIETY, JOURNAL, 1948, Princeton, N.J., 5.0%, E.

LIST OF JOURNALS IN EACH FRONT - Continued

R.F.

Solid State Physics - Concluded

- 3:10: 7 BERICHTE DER BUNSENGESELLSCHAFT FUER
PHYSIKALISCHE CHEMIE, 1894, Weinheim,
West Germany, 4.9%, G, E.
8 PHYSICA STATUS SOLIDI (A) APPLIED RESEARCH,
1970, Berlin, East Germany, 4.2%, E, F, R, G.
9 PHYSICA STATUS SOLIDI (B) BASIC RESEARCH, 1961,
Berlin, East Germany, 4.0%, E, F, G, R.
10 APPLIED OPTICS, 1962, New York, U.S.A., 3.9%,
E, F, G, R.
11 PROGRESS OF THEORETICAL PHYSICS/RIRON
BUTSURIGAKU NO SHINPO, 1946, Kyoto, Japan,
3.5%, E, summaries in European languages.
12 JOURNAL OF MATHEMATICAL PHYSICS, 1960,
New York, U.S.A., 3.3%, E.
13 JOURNAL DE PHYSIQUE, Orsay, France, 1963, 3.3%,
E, F.
14 ADVANCES IN PHYSICS, 1952, London, England,
3.1%, E.
15 AMERICAN PHYSICAL SOCIETY, BULLETIN, 1956,
New York, U.S.A., 3.0%, E.
16 I.E.E.E. PROCEEDINGS, 1913, Piscataway, N.J.,
2.8%, E.
17 JAPANESE JOURNAL OF APPLIED PHYSICS, 1962,
Tokyo, Japan, 2.8%, E, F, G.
18 OPTICS COMMUNICATIONS, 1969, Amsterdam,
Netherlands, 2.8%.
19 JOURNAL OF PHYSICS B: ATOMIC AND MOLECULAR
PHYSICS, 1968, Bristol, England, 2.8%, E.
20 SOLID STATE PHYSICS: ADVANCES IN RESEARCH AND
APPLICATIONS, 1955, New York, U.S.A., 2.7%, E.
21 ACTA METALLURGICA, 1953, Elmsford, N.Y.,
Oxford, England, 2.7%, E, F, G.
22 JOURNAL OF VACUUM SCIENCE AND TECHNOLOGY, 1964,
New York, U.S.A., 2.5%, E.
23 JOURNAL OF PHYSICS F: METAL PHYSICS, 1971,
Bristol, England, 2.2%, E.
24 I.E.E.E. JOURNAL OF QUANTUM ELECTRONICS, 1965,
Piscataway, N.J., 1.9%, E.
25 BELL SYSTEM TECHNICAL JOURNAL, 1922,
Murray Hill, N.J., 1.7%, E.
26 THIN SOLID FILMS, 1968, Lausanne, Switzerland,
1.7%, E, F, G.
27 JOURNAL OF LOW TEMPERATURE PHYSICS, 1969,
New York, U.S.A., 1.6%, E.
28 SOLID-STATE ELECTRONICS, 1960, Elmsford, N.Y.,
Oxford, England, 1.3%, E, F, G.
29 ELECTRONICS LETTERS, 1965, London, England,
1.2%, E.
30 I.E.E.E. TRANSACTIONS, ELECTRON DEVICES, 1954,
Piscataway, N.J., 1.1%, E.
31 COMMUNICATIONS IN MATHEMATICAL PHYSICS, 1965,
New York, U.S.A., 1.0%, E, F, G.

Plant Biology

- 5:11: 1 PLANT PHYSIOLOGY, 1926, Bethesda, Md., 16.0%,
E.
2 PHOTOCHEMISTRY, 1962, Elmsford, N.Y. and
Oxford, England, 12.4%, E, F, G.
3 PLANTA, 1925, New York, U.S.A. and Berlin,
West Germany, 10.3%, E, F, G.
4 AMERICAN JOURNAL OF BOTANY, 1914, Lexington,
Ky., 10.2%, E.
5 CANADIAN JOURNAL OF BOTANY/JOURNAL CANADIEN DE
BOTANIQUE, 1929, Ottawa, Canada, 8.4%, E, F.
6 ANNUAL REVIEW OF PLANT PHYSIOLOGY, 1950,
Palo Alto, Cal., 8.4%, E.
7 PHYSIOLOGIA PLANTARUM, 1948, Copenhagen,
Denmark, 8.1%, E, F, G.
8 ANNALS OF BOTANY, 1887, London, England and
New York, U.S.A., 6.0%, E.
9 JOURNAL OF EXPERIMENTAL BOTANY, 1950, London,
England, 5.8%, E.
10 THE NEW PHYTOLOGIST, 1902, Oxford, England,
5.6%, E.

R.F.

- 5:11:11 PLANT AND CELL PHYSIOLOGY, 1960, Kyoto, Japan,
4.7%, E.
12 ZEITSCHRIFT FUER PFLANZENPHYSIOLOGIE/
INTERNATIONAL JOURNAL OF PLANT PHYSIOLOGY,
1909, Stuttgart, West Germany, 4.1%, G, F, E,
summaries in G, E.

Secondary Biochemistry

- 2:12: 1 ROYAL SOCIETY OF LONDON, PROCEEDINGS, SERIES
B, BIOLOGICAL SCIENCES, 1932, London, England,
9.1%, E.
2 CANADIAN JOURNAL OF BIOCHEMISTRY/JOURNAL
CANADIEN DE BIOCHIMIE, 1929, Ottawa, Canada,
6.2%, E, F.
3 BIOPHYSICAL JOURNAL, 1960, New York, U.S.A.,
4.6%, E.
4 JOURNAL OF CELL SCIENCE, 1966, Cambridge,
England, 4.3%.
5 JOURNAL OF THEORETICAL BIOLOGY, 1961, London,
England and New York, U.S.A., 4.2%, E, F, G.
6 INTERNATIONAL REVIEW OF CYTOLOGY, 1952,
New York, U.S.A., 4.2%, E.
7 PSYCHOLOGICAL BULLETIN, 1904, Washington, D.C.,
4.1%, E.
8 ROYAL SOCIETY OF LONDON, PHILOSOPHICAL
TRANSACTIONS, SERIES B, BIOLOGICAL SCIENCES,
1665, London, England, 3.8%, E.
9 ADVANCES IN ENZYMOLOGY AND RELATED AREAS OF
MOLECULAR BIOLOGY, 1942, New York, U.S.A.,
3.7%, E.
10 JOURNAL OF MEMBRANE BIOLOGY, 1969, New York,
U.S.A., 3.6%, E.
11 BIOLOGICAL BULLETIN, 1898, Wood's Hole, Mass.,
U.S.A., 3.5%, E.
12 PSYCHOLOGICAL REVIEW, 1894, Washington, D.C.,
3.4%, E.
13 JOURNAL OF ABNORMAL PSYCHOLOGY, 1965,
Washington, D.C., 3.4%, E.
14 JOURNAL OF EXPERIMENTAL BIOLOGY, 1923,
Cambridge, England, 3.4%, E.
15 AMERICAN ZOOLOGIST, 1961, Thousand Oaks, Cal.,
3.2%, E.
16 CELL AND TISSUE RESEARCH, New York, U.S.A.,
2.8%, E.
17 PHYSIOLOGY AND BEHAVIOR, 1966, Elmsford, N.Y.
and Oxford, England, 2.7%, E.
18 JOURNAL OF COMPARATIVE AND PHYSIOLOGICAL
PSYCHOLOGY, 1908, Washington, D.C., 2.7%, E.
19 ADVANCES IN PROTEIN CHEMISTRY, 1972, New York,
U.S.A., 2.7%, E.
20 JOURNAL OF PERSONALITY AND SOCIAL PSYCHOLOGY,
1965, Washington, D.C., 2.7%, E.
21 JOURNAL OF COMPARATIVE PHYSIOLOGY A: SENSORY,
NEUTRAL, AND BEHAVIORAL PHYSIOLOGY, 1924,
New York, U.S.A., 2.5%, E, G, summaries in E.
22 JOURNAL OF CONSULTING AND CLINICAL PSYCHOLOGY,
1937, Washington, D.C., 2.4%, E.
23 JOURNAL OF INSECT PHYSIOLOGY, 1957, Elmsford,
N.Y. and Oxford, England, 2.3%, E.
24 JOURNAL OF MORPHOLOGY, 1887, New York, U.S.A.,
2.3%, E.
25 AMERICAN PSYCHOLOGIST, 1946, Washington, D.C.,
2.2%, E.
26 PSYCHOLOGICAL REPORTS, 1955, Missoula, Montana,
2.1%, E.
27 JOURNAL OF EMBRYOLOGY AND EXPERIMENTAL
MORPHOLOGY, 1953, Cambridge, England, 2.0%, E,
F, G, R.
28 CHILD DEVELOPMENT, 1930, Chicago, Ill., 2.0%,
E.
29 PERCEPTUAL AND MOTOR SKILLS, 1949, Missoula,
Montana, 1.6%, E.
30 DEVELOPMENTAL PSYCHOLOGY, 1969,
Washington, D.C., 1.4%, E.
31 PERCEPTION AND PSYCHOPHYSICS, 1966, Austin,
Texas, 0.8%, E.

LIST OF JOURNALS IN EACH FRONT - Continued

R.F.

Geology and Astrophysics

- 8:13: 1 JOURNAL OF GEOPHYSICAL RESEARCH, 1909, Washington, D.C., 13.8%, E.
 2 ASTROPHYSICAL JOURNAL, 1895, Chicago, Ill., 12.4%, E.
 3 GEOCHIMICA ET COSMOCHIMICA ACTA, 1950, Oxford, England, 7.4%, E, F, G.
 4 GEOLOGICAL SOCIETY OF AMERICA BULLETIN, 1888, Boulder, Col., 6.6%, E.
 5 EARTH AND PLANETARY SCIENCE LETTERS, 1965, Amsterdam, Netherlands, 5.9%, summaries in E, F, G.
 6 ROYAL ASTRONOMICAL SOCIETY, MONTHLY NOTICES, 1827, Oxford, England, 5.8%, E.
 7 AMERICAN MINERALOGIST, 1916, Washington, D.C., 5.2%.
 8 AMERICAN JOURNAL OF SCIENCE, 1818, New Haven, Conn., 5.0%, E.
 9 ASTRONOMY AND ASTROPHYSICS, 1969, Springer-Verlag, New York, 4.8%, E, F, G, summaries in E.
 10 JOURNAL OF GEOLOGY, 1893, Chicago, Ill., 4.3%, E.
 11 ROYAL ASTRONOMICAL SOCIETY GEOPHYSICAL JOURNAL, 1958, Oxford, England, 3.2%, E.
 12 ASTRONOMICAL JOURNAL, 1849, New York, U.S.A., 2.9%, E.
 13 CONTRIBUTION TO MINERALOGY AND PETROLOGY/BEITRAEGE ZUR MINERALOGIE UND PETROGRAPHIE, 1947, Berlin, West Germany, New York, U.S.A., 2.9%, E, G.
 14 AAPG BULLETIN, 1917, Tulsa, Ok., 2.7%, E.
 15 CANADIAN JOURNAL OF EARTH SCIENCES/JOURNAL CANADIEN DES SCIENCES DE LA TERRE, 1964, Ottawa, Canada, 3.6%, E, F.
 16 JOURNAL OF SEDIMENTARY PETROLOGY, 1931, Tulsa, Ok., 2.2%, E.
 17 SOLAR PHYSICS, 1967, Dordrecht, Netherlands, 2.1%, E.
 18 ANNUAL REVIEW OF ASTRONOMY AND ASTROPHYSICS, 1963, Palo Alto, Cal., 2.1%, E.
 19 ASTROPHYSICS AND SPACE SCIENCE, 1968, Dordrecht, Netherlands, 2.0%, E.
 20 JOURNAL OF PETROLOGY, 1960, London, England, 2.0%, E.
 21 ASTRONOMICAL SOCIETY OF THE PACIFIC PUBLICATIONS, 1889, San Francisco, Cal., 1.6%, E.
 22 SEISMOLOGICAL SOCIETY OF AMERICA, BULLETIN, 1911, Berkeley, Cal., 1.4%, E.
 23 ASTROPHYSICAL LETTERS, 1967, London, England, 1.1%, E.

Pharmacology

- 3:14: 1 ANALYTICAL CHEMISTRY, 1929, Washington, D.C., 15.1%, E.
 2 JOURNAL OF CHROMATOGRAPHY, 1958, Amsterdam, Netherlands, 8.6%, E, F, G, summaries in E.
 3 CLINICAL PHARMACOLOGY AND THERAPEUTICS, 1960, St. Louis, Mo., 7.4%, E.
 4 JOURNAL OF MEDICINAL CHEMISTRY, 1958, Washington, D.C., 6.6%, E.
 5 ARZNEIMITTEL-FORSCHUNG/DRUG RESEARCH, 1951, Aulendorf, West Germany, 5.1%, E, G.
 6 CANADIAN JOURNAL OF PHYSIOLOGY AND PHARMACOLOGY/JOURNAL CANADIEN DE PHYSIOLOGIE ET PHARMACOLOGIE, 1964, Ottawa, Canada, 5.0%, E, F.
 7 JOURNAL OF PHARMACEUTICAL SCIENCES, 1974, Washington, D.C., 4.9%, E.
 8 ACTA PHARMACOLOGICA ET TOXICOLOGICA, 1944, Copenhagen, Denmark, 4.8%, E.
 9 TOXICOLOGY AND APPLIED PHARMACOLOGY, 1959, New York, U.S.A., 4.3%, E.
 10 ANNUAL REVIEW OF PHARMACOLOGY, 1961, Palo Alto, Cal., 4.1%, E.

R.F.

- 3:14:11 ARCHIVES OF ENVIRONMENTAL HEALTH, 1950, Washington, D.C., 3.9%, E.
 12 RESEARCH COMMUNICATIONS IN CHEMICAL PATHOLOGY AND PHARMACOLOGY, 1970, Westbury, N.Y., 3.7%, E, F, G.
 13 NEUROPHARMACOLOGY, 1962, Elmsford, N.Y. and Oxford, England, 3.4%, E.
 14 JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY, 1953, Washington, D.C., 3.3%, E.
 15 ANALYTICA CHIMICA ACTA, 1947, Amsterdam, Netherlands, 3.1%, E, F, G, summaries in E.
 16 ANALYST, 1876, London, England, 2.9%, E.
 17 PHARMACOLOGIST, 1959, Bethesda, Md., 2.2%, E.
 18 FRESENIUS' ZEITSCHRIFT FÜR ANALYTISCHE CHEMIE, 1862, Berlin, West Germany and New York, U.S.A., 2.1%, E, G.
 19 TALANTA, 1954, Elmsford, N.Y. and Oxford, England, 1.9%, E.
 20 JOURNAL OF THE SCIENCE OF FOOD AND AGRICULTURE, 1950, Oxford, England, 1.9%, E.
 21 JOURNAL OF CHROMATOGRAPHIC SCIENCE, 1963, Niles, Ill., 1.6%, E.
 22 ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS JOURNAL, 1915, Washington, D.C., 1.6%, E.
 23 JOURNAL OF FOOD SCIENCE, 1936, Chicago, Ill., 1.2%, E.
 24 CEREAL CHEMISTRY, 1924, St. Paul, Minn., 0.7%, E.
 25 FOOD TECHNOLOGY, 1947, Chicago, Ill., 0.5%, E.

Microbiology and Macromolecular Science

- 2:15: 1 BACTERIOLOGICAL REVIEWS, 1937, Washington, D.C., 8.9%, E.
 2 GENETICS, 1916, Austin, Texas, 8.8%, E.
 3 BIOPOLYMERS, 1961, New York, U.S.A., 7.9%, E.
 4 MOLECULAR AND GENERAL GENETICS, 1908, New York, U.S.A., 6.8%, E, F, G, summaries in E.
 5 CANADIAN JOURNAL OF MICROBIOLOGY/JOURNAL CANADIEN DE MICROBIOLOGIE, 1954, Ottawa, Canada, 6.6%, E, F.
 6 ARCHIVES OF MICROBIOLOGY, 1939, Berlin, West Germany and New York, U.S.A., 6.5%, E, G.
 7 ANNUAL REVIEW OF MICROBIOLOGY, 1947, Palo Alto, Cal., 6.2%, E.
 8 CHROMASOMA, 1939, New York, U.S.A., 5.9%, E, F, G.
 9 MAKROMOLEKULARE CHEMIE, 1947, Basel, Switzerland, 5.6%, E, F, G.
 10 MACROMOLECULES, 1968, Washington, D.C., 5.4%, E.
 11 NUCLEAR ACIDS RESEARCH, 1974, London, England, 5.0%, E.
 12 MUTATION RESEARCH, 1964, Amsterdam, Netherlands, 4.9%, E, F, G.
 13 JOURNAL OF POLYMER SCIENCE, POLYMER SYMPOSIA EDITION, 1973, New York, U.S.A., 3.7%, E.
 14 JOURNAL OF APPLIED POLYMER SCIENCE, 1956, New York, U.S.A., 3.5%, E.
 15 JOURNAL OF POLYMER SCIENCE, POLYMER PHYSICS EDITION, 1962, New York, U.S.A., 3.4%, E, F, G.
 16 JOURNAL OF POLYMER SCIENCE, POLYMER LETTERS EDITION, 1962, New York, U.S.A., 3.1%, E.
 17 POLYMER, 1960, Guildford, England, 3.1%, E.
 18 JOURNAL OF POLYMER SCIENCE, POLYMER CHEMISTRY EDITION, 1962, New York, U.S.A., 2.8%, E, F, G.
 19 EUROPEAN POLYMER JOURNAL, 1965, Elmsford, N.Y. and Oxford, England, 2.0%, E, F, G, I.

Main Law

- 12:16: 1 HARVARD LAW REV
 2 YALE LAW J
 3 COLUMBIA LAW REV
 4 U PENN LAW REV
 5 MICH LAW REV

LIST OF JOURNALS IN EACH FRONT - Continued

R.F.

Main Law - Concluded

- 12:16: 6 U CHICAGO LAW REV
7 VA LAW REV
8 STANFORD LAW REV
9 CALIF LAW REV
10 TEX LAW REV
11 NEW YORK U LAW REV
12 CORNELL LAW REV

Main Mathematics

- 6:17: 1 AMERICAN MATHEMATICAL SOCIETY, TRANSACTION,
1900, Providence, R.I., 14%, E.
2 ANNALS OF MATHEMATICS, 1884, Princeton, N.J.,
12.2%, E.
3 AMERICAN MATHEMATICAL SOCIETY, PROCEEDINGS,
1950, Providence, R.I., 11.2%, E.
4 LECTURE NOTES IN MATHEMATICS,* 1964, New York,
U.S.A., 10.0%, E, G, F.
5 AMERICAN MATHEMATICAL SOCIETY BULLETIN, 1894,
Providence, R.I., 9.9%, E.
6 MATHEMATISCHE ANNALEN, 1920, Berlin,
West Germany, New York, U.S.A., 9.7%, E, F, G.
7 AMERICAN JOURNAL OF MATHEMATICS, 1878,
Baltimore, Md., 8.4%, E.
8 PACIFIC JOURNAL OF MATHEMATICS, 1951,
Carmel Valley, Cal., 8.2%, E.
9 MATHEMATISCHE ZEITSCHRIFT, 1918, Berlin,
West Germany, New York, U.S.A., 8.0%, E, F, G.
10 ACTA MATHEMATICA, 1882, Djursholm, Sweden,
6.4%.
11 DUKE MATHEMATICAL JOURNAL, 1935, Durham, N.C.,
6.0%, E.
12 CANADIAN JOURNAL OF MATHEMATICS/JOURNAL
CANADIEN DE MATHEMATIQUES, 1949, Toronto,
Ontario, 5.6%, E, F.

Neurosurgery

- 11:18: 1 ARCHIVES OF NEUROLOGY, 1959, Chicago, Ill.,
15.6%, E.
2 NEUROLOGY, 1951, Minneapolis, Minn., 15.3%, E.
3 JOURNAL OF NEUROLOGY, NEUROSURGERY AND
PSYCHIATRY, 1926, London, England, 9.4%, E.
4 BRAIN, 1878, London, England, 9.1%, E.
5 JOURNAL OF NEUROSURGERY, 1944, Hanover, N.H.,
8.7%, E.
6 JOURNAL OF BONE AND JOINT SURGERY: AMERICAN
VOLUME, 1903, Boston, Mass., 7.6%, E.
7 JOURNAL OF NEUROLOGICAL SCIENCES, 1957,
Turin, Italy, 6.7%, E.
8 ELECTROENCEPHALOGRAPHY AND CLINICAL
NEUROPHYSIOLOGY, 1949, Limerick, Ireland, 6.5%,
E, F.
9 JOURNAL OF NEUROPATHOLOGY AND EXPERIMENTAL
NEUROLOGY, 1942, New York, U.S.A., 4.8%, E.
10 CLINICAL ORTHOPAEDICS AND RELATED RESEARCH,
1953, Philadelphia, Pa., 4.3%, E.
11 JOURNAL OF BONE AND JOINT SURGERY: BRITISH
VOLUME, 1903, Edinburgh, Scotland, 4.2%, E.
12 ACTA NEUROPATHOLOGICA, 1961, New York, U.S.A.,
4.1%, E, F, G.
13 ACTA NEUROLOGICA SCANDINAVICA, 1961,
Copenhagen, Denmark, 3.7%, E.

Nutrition, Clinical Medicine and Public Health

- 2:19: 1 KLINISCHE WOCHENSCHRIFT, 1922, Berlin,
West Germany, New York, U.S.A., 4.8%, E, G.
2 BRITISH MEDICAL BULLETIN, 1943, London,
England, 4.3%, E.
3 MEDICAL JOURNAL OF AUSTRALIA, 1914, Glebe,
Australia, 4.2%, E.

R.F.

- 2:19: 4 MEDICAL CLINICS OF NORTH AMERICA, 1916,
Philadelphia, Pa., 4.1%, E.
5 AMERICAN JOURNAL OF CLINICAL NUTRITION, 1952,
Bethesda, Md., 4.0%, E.
6 PEDIATRIC RESEARCH, 1967, Baltimore, U.S.A.,
3.8%, E.
7 POSTGRADUATE MEDICAL JOURNAL, 1924, Oxford,
England, 3.8%, E.
8 JOURNAL OF NUTRITION, 1928, Bethesda, Md.,
3.7%, E.
9 BRITISH JOURNAL OF EXPERIMENTAL PATHOLOGY,
1920, London, England, 3.6%, E.
10 THROMBOSIS AND HAEMOSTASIS, 1957, Stuttgart,
West Germany, 3.3%, E.
11 DEUTSCHE MEDIZINISCHE WOCHENSCHRIFT, 1875,
Stuttgart, West Germany, 3.2%, editions in E,
G, Gr., I, S.
12 JOURNAL OF CHRONIC DISEASES, 1955, Elmsford,
N.Y. and Oxford, England, 2.8%, E.
13 SOUTH AFRICAN MEDICAL JOURNAL/SUID-AFRIKAANSE
MEDIESE TYPESKRIF, 1927, Cape Town, South
Africa, 2.8%, Afrikaans and E.
14 ACTA CHIRURGICA SCANDINAVICA, 1869, Stockholm,
Sweden, 2.7%, E.
15 WORLD HEALTH ORGANIZATION, BULLETIN, 1947,
Geneva, Switzerland, 2.7%, E, F, separate
edition in R.
16 SCHWEIZERISCHE MEDIZINISCHE WOCHENSCHRIFT,
1870, Basel, Switzerland, 2.5%, F, G, summaries
in original language and E.
17 AMERICAN JOURNAL OF EPIDEMIOLOGY, 1921,
Baltimore, Md., 2.4%, E.
18 THORAX, 1946, London, England, 2.4%, E.
19 ACTA PAEDIATRICA SCANDINAVICA, 1921, Stockholm,
Sweden, 2.3%, E.
20 SOUTHERN MEDICAL JOURNAL, 1906, Alabama,
U.S.A., 2.3%, E.
21 SURGICAL FORUM, 1950, Philadelphia, U.S.A.,
2.1%, E.
22 SEMINARS IN HAEMATOLOGY, 1964, New York,
U.S.A., 2.1%, E.
23 SURGICAL CLINICS OF NORTH AMERICA, 1920,
Philadelphia, U.S.A., 1.9%, E.
24 SCANDINAVIAN JOURNAL OF HAEMATOLOGY, 1964,
Copenhagen, Denmark, 1.9%, E.
25 RETICULOENDOTHELIAL SOCIETY, JOURNAL, 1964,
Winston-Salem, N.C., 1.7%, E.
26 JOURNAL OF SURGICAL RESEARCH, 1961, New York,
U.S.A., 1.5%, E.
27 THROMBOSIS RESEARCH, 1972, Elmsford, N.Y. and
Oxford, England, 1.5%, E, F, G, R, summaries in
E.
28 BRITISH JOURNAL OF NUTRITION, 1947, Cambridge,
England, 1.4%, E.
29 ANNALS OF THORACIC SURGERY, 1965, Boston,
Mass., 1.4%, E.
30 JOURNAL OF PROTOZOLOGY, 1954, Lawrence,
Kansas, 1.4%, E, F, G, summaries in E.
31 ACTA HAEMATOLOGICA, 1948, Basel, Switzerland,
1.4%, E, summaries in E and original language.
32 AMERICAN JOURNAL OF TROPICAL MEDICINE AND
HYGIENE, 1921, Lawrence, Kansas, 1.4%, E.
33 AMERICAN JOURNAL OF PUBLIC HEALTH, 1911,
Washington, D.C., 1.4%, E.
34 JOURNAL OF PEDIATRIC SURGERY, 1966, New York,
1.3%, E.
35 JOURNAL OF PARASITOLOGY, 1914, Lawrence,
Kansas, 1.3%, E.
36 JOURNAL OF TRAUMA, 1961, Baltimore, Md., 1.3%,
E.
37 ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE
TRANSACTIONS, 1907, London, England, 1.3%, E.
38 JOURNAL OF DAIRY SCIENCE, 1917, Champaign,
Ill., 1.1%, E.
39 MEDIZINISCHE KLINIK, 1906, Munich,
West Germany, 1.0%, E.

LIST OF JOURNALS IN EACH FRONT - Continued

R.F.

Nutrition, Clinical Medicine and Public Health - Concluded

- 2:19:40 EXPERIMENTAL PARASITOLOGY, 1951, New York, U.S.A., 1.0%, E.
 41 AMERICAN SURGEON, 1935, Philadelphia, Pa., 1.0%, E.
 42 JOURNAL OF ANIMAL SCIENCE, 1942, Champaign, Ill., 0.9%, E.
 43 PARASITOLOGY, 1908, London, England, 0.9%, E.
 44 JOURNAL OF AGRICULTURAL SCIENCE, 1905, Cambridge, England, 0.8%, E.
 45 AUSTRALIAN JOURNAL OF AGRICULTURAL RESEARCH, Melbourne, Australia, 0.6%, E.
 46 ANNALS OF TROPICAL MEDICINE AND PARASITOLOGY, London, England, 0.6%, E.

Physical Chemistry

- 5:20: 1 NATURWISSENSCHAFTEN, 1913, Berlin, West Germany, 10.6%,
 2 ZEITSCHRIFT FÜR NATURFORSCHUNG, SECTION B; INORGANIC AND ORGANIC CHEMISTRY, Tuebingen, West Germany, 1973, 8.7%, E, G.
 3 PURE AND APPLIED CHEMISTRY, 1960, Elmsford, N.Y. and Oxford, England, 6.7%, E.
 4 ACADEMIE DES SCIENCES, COMPTES RENDUS HEBDOMADAIRES DES SEANCES, SERIES C: SCIENCES CHIMIQUES, 1835, Cedex, France, 5.9%, F.
 5 ADVANCES IN CHEMISTRY SERIES, 1950, Washington, D.C., 5.1%, E.
 6 JOURNAL DE CHIMIE PHYSIQUE ET DE PHYSIOCHIMIE BIOLOGIQUE, 1903, Paris, France, 4.9%, F.
 7 PHOTOCHEMISTRY AND PHOTOBIOLOGY, 1962, Elmsford, N.Y. and Oxford, England, 4.6%, E, F, G.
 8 SPECTROCHIMICA ACTA, PART A: MOLECULAR SPECTROSCOPY, 1939, Elmsford, N.Y. and Oxford, England, 4.4%, E, F, G.
 9 JOURNAL OF MAGNETIC RESONANCE, 1969, New York, U.S.A., 4.3%, E.
 10 MONATSHFTE FÜR CHEMIE, 1880, Berlin, West Germany, New York, U.S.A., 4.2%, E, G.
 11 JOURNAL OF CHEMICAL EDUCATION, 1924, New York, U.S.A., 4.1%, E.
 12 CHEMICAL SOCIETY, LONDON, JOURNAL: FARADAY TRANSACTIONS 2, 1972, London, England, 4.1%, E.
 13 CHEMICAL SOCIETY, LONDON, JOURNAL: FARADAY TRANSACTIONS 1, 1972, London, England, 3.5%, E.
 14 GAZZETTA CHIMICA ITALIANA, 1871, Rome, Italy, 3.4%, E.
 15 JOURNAL OF MOLECULAR STRUCTURE, 1967, Amsterdam, Netherlands, 3.4%, E, F, G.
 16 CHEMISTRY LETTERS, 1972, Tokyo, Japan, 3.4%, E, J, G, F.
 17 JOURNAL FÜR PRAKTISCHE CHEMIE, 1828, Leipzig, East Germany, 3.2%, G.
 18 JOURNAL OF HETEROCYCLIC CHEMISTRY, 1964, Provo, Utah, 3.1%, E, F, G.
 19 JOURNAL OF ELECTRON SPECTROSCOPY AND RELATED PHENOMENA, 1972, Amsterdam, Netherlands, 2.8%, E, F, G.
 20 ZEITSCHRIFT FÜR CHEMIE, 1961, Leipzig, East Germany, 2.5%, G.
 21 ANNUAL REVIEW OF PHYSICAL CHEMISTRY, 1950, Palo Alto, Cal., 2.4%, E.
 22 ADVANCES IN CHEMICAL PHYSICS,* 1958, New York, U.S.A., 2.3%, E.
 23 ORGANIC MAGNETIC RESONANCE, 1969, London, England, 2.3%, E.
 24 INTERNATIONAL JOURNAL OF QUANTUM CHEMISTRY, 1966, New York, U.S.A., 2.2%, E, F, G, summaries in E, F, G.

Ecology

- 2:21: 1 ECOLOGY, Durham, N.C., 9.4%, E.

R.F.

- 2:21: 2 AMERICAN NATURALIST, 1867, Chicago, Ill., 8.5%, E.
 3 CANADA, FISHERIES RESEARCH BOARD, JOURNAL, 1919, Ottawa, Canada, 6.7%, E, F.
 4 CANADIAN JOURNAL OF ZOOLOGY/JOURNAL CANADIEN DE ZOOLOGIE, 1929, Ottawa, Canada, 6.6%, E, F.
 5 LIMNOLOGY AND OCEANOGRAPHY, 1956, Milwaukee, Wisc., 6.5%, E.
 6 EVOLUTION, 1947, Kansas, U.S.A., 5.4%, E.
 7 MARINE BIOLOGY, 1967, New York, U.S.A., 5.4%, E.
 8 MARINE BIOLOGICAL ASSOCIATION OF THE UNITED KINGDOM, JOURNAL, 1887, Cambridge, England, 5.3%, E.
 9 ENTOMOLOGICAL SOCIETY OF AMERICA, ANNALS, 1908, College Park, Mo., 4.6%, E.
 10 JOURNAL OF ECONOMIC ENTOMOLOGY, 1908, College Park, Mo., 4.6%, E.
 11 JOURNAL OF ANIMAL ECOLOGY, 1932, Oxford, England, 4.4%.
 12 ECOLOGICAL MONOGRAPHS, 1931, Durham, N.C., 4.1%, E.
 13 DEEP-SEA RESEARCH, 1953, Elmsford, N.Y. and Oxford, England, 3.9%, E.
 14 AMERICAN MIDLAND NATURALIST, 1909, Notre Dame, Ind., 3.8%, E.
 15 JOURNAL OF ECOLOGY, 1913, Oxford, England, 3.8%, E.
 16 COPEIA, 1913, Washington, D.C., 3.2%, E.
 17 ANNUAL REVIEW OF ENTOMOLOGY, 1956, Palo Alto, Cal., 3.1%, E.
 18 JOURNAL OF MAMMALOGY, 1919, Pittsburgh, Pa., 2.6%, E.
 19 CANADIAN ENTOMOLOGIST, 1868, Ottawa, Canada, 2.6%, E, F.
 20 AMERICAN FISHERIES SOCIETY, TRANSACTIONS, 1870, Columbia, Mo., 2.4%, E.
 21 JOURNAL OF MARINE RESEARCH, 1937, New Haven, Conn., 2.0%, E.
 22 ENVIRONMENTAL ENTOMOLOGY, 1972, College Park, Md., 1.3%, E.

Ophthalmology

- 13:22: 1 ARCHIVES OF OPHTHALMOLOGY, 1869, Chicago, Ill., 19.1%, E.
 2 AMERICAN JOURNAL OF OPHTHALMOLOGY, 1884, Chicago, Ill., 18.8%, E.
 3 EXPERIMENTAL EYE RESEARCH, 1961, London, England, 13.7%, E.
 4 INVESTIGATIVE OPHTHALMOLOGY AND VISUAL SCIENCE, 1962, St. Louis, Mo., 12.3%, E.
 5 BRITISH JOURNAL OF OPHTHALMOLOGY, 1917, London, England, 11.8%, E.
 6 AMERICAN ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY, TRANSACTIONS, 1906, Rochester, Minn., 5.8%, E.
 7 ACTA OPHTHALMOLOGICA (INCLUDES DANISH OPHTHALMOLOGICAL SOCIETY, TRANSACTIONS), 1923, Copenhagen, Denmark, 4.8%, E.
 8 KLINISCHE MONATSBLETTET FÜR ANGENHEILKUNDE UND FÜR AUGENARZTLICHE FORTBILDUNG, 1863, Stuttgart, West Germany, 3.9%, E, G.
 9 OPHTHALMOLOGICA, 1899, Basel, Switzerland, 3.6%, E, F, G.
 10 OPHTHALMOLOGICAL SOCIETIES OF THE UNITED KINGDOM, TRANSACTIONS, 1880, London, England, 3.1%, E.
 11 ALBRECHT VON GRAEFES ARCHIV FÜR KLINISCHE UND EXPERIMENTELLE OPHTHALMOLOGIE/ALBRECHT VON GRAEFES ARCHIVE FOR CLINICAL AND EXPERIMENTAL OPHTHALMOLOGY, Berlin, West Germany, 3.1%, G, summaries in E.

Physics of Materials

- 9:23: 1 ANNALEN DER PHYSIK, 1790, Verlag, East Germany, 6.2%, G.

LIST OF JOURNALS IN EACH FRONT - Continued

R.F.

Physics of Materials - Concluded

- 9:24: 2 JOURNAL OF PHYSICS D: APPLIED PHYSICS, 1950, Bristol, England, 5.1%, E.
 3 MATERIALS RESEARCH BULLETIN, 1966, Elmsford, N.Y. and Oxford, England, 5.1%, E, F, G, R.
 4 ACADEMIE DES SCIENCES, COMPTES RENDUS HEBDOMADAIRES DES SEANCES, SERIES B: SCIENCES PHYSIQUES, 1835, Cedex, France, 4.9%, E, F.
 5 AMERICAN CERAMIC SOCIETY, JOURNAL, 1918, Columbus, Ohio, 4.7%, E.
 6 JOURNAL OF THE LESS COMMON METALS, 1959 Lausanne, Switzerland, 4.5%, E, F, G, summaries in E.
 7 REPORTS ON PROGRESS IN PHYSICS, 1934, Bristol, England, 4.5%, E.
 8 JOURNAL OF SOLID STATE CHEMISTRY, 1969, New York, U.S.A., 4.3%, E, F, G.
 9 JOURNAL OF MATERIALS SCIENCE, 1966, London, England, 4.2%, E.
 10 J.E.I.P. LETTERS, 1965, U.S.S.R. (English Translation, New York, U.S.A.), 4.1%.
 11 JOURNAL OF PHYSICS E: SCIENTIFIC INSTRUMENTS, 1923, Bristol, England, 4.1%, E.
 12 ZEITSCHRIFT FUER KRISTALLOGRAPHIE/JOURNAL OF CRYSTALLOGRAPHY, 1955, West Germany, 4.1%, E.
 13 JOURNAL OF CRYSTAL GROWTH, 1967, Amsterdam, Netherlands, 4.0%, E.
 14 PHYSICS REPORTS, Amsterdam, Netherlands, 3.8%, E.
 15 JOURNAL OF PHYSICS A: MATHEMATICAL AND GENERAL, 1968, Bristol, England, 3.6%, E.
 16 HELEVETICA PHYSICA ACTA, 1928, Basel, Switzerland, 3.5%, E, F, G, I.
 17 JOURNAL OF NON-CRYSTALLINE SOLIDS, 1969, Amsterdam, Netherlands, 3.4%, E.
 18 SOCIETA ITALIANA DI FISICA, NUOVO CIMENTO B, 1855, Bologna, Italy, 3.2%, E, F, G, summaries in E, I, R.
 19 LETTERE AL NUOVO CIMENTO, 1969, Bologna, Italy, 3.1%, I, E.
 20 JOURNAL OF APPLIED CRYSTALLOGRAPHY, 1968, Copenhagen, Denmark, 2.9%, E.
 21 ZEITSCHRIFT FUER METALLKUNDE, 1911, Stuttgart, West Germany, 2.9%, summaries in E.
 22 I.E.E.E. TRANSACTIONS, MAGNETICS, 1965, Piscataway, N.J., 2.7%, E.
 23 PHYSICA SCRIPTA, 1970, Stockholm, Sweden, 2.4%, E.
 24 SOCIETA ITALIANA DI FISICA, NUOVO CIMENTO A, Bologna, Italy, 2.2%, E, F, G, summaries in E, I, R.
 25 SCRIPTA METALLURGICA, 1967, Elmsford, N.Y. and Oxford, England, 2.0%, E.
 26 MATERIALS SCIENCE AND ENGINEERING, 1967, Lausanne, Switzerland, 1.3%, E, F, G.
 27 ANNUAL REVIEW OF NUCLEAR SCIENCE, 1952, Palo Alto, Cal., 1.2%, E.
 28 ZEITSCHRIFT FUER PHYSIK, SECTION A: ATOMS AND NUCLEI, 1920, Berlin, West Germany and New York, U.S.A., 1.0%, E, G, summaries in E.
 29 SOVIET JOURNAL OF NUCLEAR PHYSICS, 1965, U.S.S.R. (English transaction, New York, U.S.A.), 1.0%.

Secondary Biochemistry, Human Genetics

- 2:24: 1 PROSTAGLANDINS, 1972, Los Altos, Cal., 5.1%, E.
 2 BIOLOGISCHE LISTRY/BIOLOGICAL REVIEW, 1912, Prague, Czech., 4.8%, Czech or Slovak, summaries in E.
 3 STEROIDS, 1963, San Francisco, Cal., 4.5%, E.
 4 DIABETOLOGIA, 1965, New York, U.S.A., 4.5%, E.
 5 ANNUAL REVIEW OF PHYSIOLOGY, 1939, Palo Alto, Cal., 4.4%, E.
 6 BIOCHEMICAL SOCIETY, LONDON, TRANSACTIONS, 1973, Colchester, England, 4.4%, E.

R.F.

- 2:24: 7 ADVANCES IN CYCLIC NUCLEOTIDE RESEARCH, 1972, New York, U.S.A., 4.2%, E.
 8 STAIN TECHNOLOGY, 1926, Baltimore, Mo., 3.5%, E.
 9 BIOCHIMIE, 1914, Paris, France, 3.4%, F, summaries in E, G.
 10 HORMONE AND METABOLIC RESEARCH, 1969, Stuttgart, West Germany, 3.3%, E, F, G, summaries in E.
 11 METHODS OF BIOCHEMICAL ANALYSIS,* 1954, New York, U.S.A., 3.2%, E.
 12 JOURNAL OF STEROID BIOCHEMISTRY, 1970, Elmsford, N.Y. and Oxford, England, 3.1%, E.
 13 EUROPEAN JOURNAL OF CLINICAL INVESTIGATION, 1971, Oxford, England, 3.1%, E.
 14 AMERICAN JOURNAL OF HUMAN GENETICS, 1949, Chicago, Ill., 3.1%, E.
 15 PROGRESS IN BRAIN RESEARCH,* 1963, Amsterdam, Netherlands, 3.0%, E.
 16 PROGRESS IN BIOPHYSICS AND MOLECULAR BIOLOGY, 1950, Elmsford, N.Y. and Oxford, England, 3.0%.
 17 QUARTERLY JOURNAL OF EXPERIMENTAL PHYSIOLOGY AND COGNATE MEDICAL SCIENCES, 1908, Edinburgh, Scotland, 2.9%, E.
 18 COMPARATIVE BIOCHEMISTRY AND PHYSIOLOGY, PART B: COMPARATIVE BIOCHEMISTRY, 1971, Elmsford, N.Y. and Oxford, England, 2.8%, E, F, G.
 19 BIRTH DEFECTS,* 1965, White Plains, N.Y., 2.7%, E.
 20 COMPARATIVE BIOCHEMISTRY AND PHYSIOLOGY, PART A: COMPARATIVE PHYSIOLOGY, 1971, Elmsford, N.Y. and Oxford, England, 2.6%, E, F, G.
 21 PROGRESS IN NUCLEIC ACID RESEARCH AND MOLECULAR BIOLOGY, 1963, New York, U.S.A., 2.6%, E.
 22 BIOCHEMICAL GENETICS, 1976, New York, U.S.A., 2.5%, E.
 23 NEUROENDOCRINOLOGY, 1965, Basel, Switzerland, 2.5%, E.
 24 ACTA ANATOMICA, 1945, Basel, Switzerland, 2.5%, text in E, F, G, summaries in E, G, original language.
 25 HEREDITAS, 1920, Lund, Sweden, 2.3%, E.
 26 ANNALS OF HUMAN GENETICS, 1925, Cambridge, England, 2.3%, E.
 27 CHEMISTRY AND PHYSICS OF LIPIDS, 1966, Limerick, Ireland, 2.1%, E.
 28 JOURNAL OF HEREDITY, 1910, Washington, D.C., 2.0%, E.
 29 ANNUAL REVIEW OF GENETICS, 1967, Palo Alto, Cal., 1.9%, E.
 30 HEREDITY, 1947, Edinburgh, Scotland, 1.8%, E.
 31 QUARTERLY REVIEWS OF BIOPHYSICS, 1968, Cambridge, England, 1.8%, E, F, G.
 32 JOURNAL OF SUPRAMOLECULAR STRUCTURE, 1972, New York, U.S.A., 1.8%, E.
 33 JOURNAL OF MEDICAL GENETICS, 1964, London, England, 1.7%, E.
 34 PHYSIOLOGICAL ZOOLOGY, 1928, Chicago, Ill., 1.7%, E.
 35 CYTOGENETICS AND CELL GENETICS, 1962, Basel, Switzerland, 1.5%, E, F, G.
 36 GENETICAL RESEARCH, 1960, Cambridge, England, 1.5%, E.
 37 ANNUAL REVIEW OF BIOPHYSICS AND BIOENGINEERING, 1972, Palo Alto, Cal., 1.4%, E.
 38 CANADIAN JOURNAL OF GENETICS AND CYTOLOGY/JOURNAL CANADIEN DE GENETIQUE ET DE CYTOLOGIE, 1959, Ottawa, Canada, 1.3%, E, F.
 39 CLINICAL GENETICS, 1970, Copenhagen, Denmark, 1.3%, E.
 40 ANNALES DE GENETIQUE, 1958, Paris, France, 0.5%, E, F.

Physical Chemistry: U.S.S.R.

- 5:25: 1 DOKL AKAD NAUK SSSR
 2 J COLLOID INTERF SCI

LIST OF JOURNALS IN EACH FRONT - Continued

R.F.

Physical Chemistry: U.S.S.R. - Concluded

- 5:25: 3 ZH EKSP TEOR FIZ
 4 ZH OBSHCH KHIM
 5 J CATAL
 6 J ELECTROANAL CH INF
 7 ZH FIZ KHIM
 8 ELECTROCHIM ACTA
 9 FIZ TVERD TELA
 10 ZH ORG KHIM
 11 OPT SPEKTROSK
 12 ZH NEDRG KHIM
 13 IZV AN SSSR FIZ
 14 USP KHIM
 15 USP FIZ HAUKE
 16 KRISTALLOGRAFIYA
 17 VYSOKOMOL SOEDIN A
 18 ZH TEKHN FIZ
 19 KHIM GETEROTSIKL
 20 VYSOKOMOL SOEDIN B
 21 KVANTOVAYA ELEKTRON*

Psychiatry, Psychology

- 2:26: 1 AMERICAN JOURNAL OF PSYCHIATRY, 1844,
 Washington, D.C., 12.3%, E.
 2 ARCHIVES OF GENERAL PSYCHIATRY, 1959, Chicago,
 Ill., 11.8%, E.
 3 PSYCHOSOMATIC MEDICINE, 1938, New York, U.S.A.,
 7.4%, E.
 4 JOURNAL OF NERVOUS AND MENTAL DISEASE, 1874,
 Baltimore, Md., 6.3%, E.
 5 BRITISH JOURNAL OF PSYCHIATRY, 1853, Ashford,
 England, 6.2%, E.
 6 AMERICAN JOURNAL OF ORTHOPSYCHIATRY, 1930,
 New York, U.S.A., 3.9%.
 7 JOURNAL OF PERSONALITY, 1932, Durham, S.C.,
 3.5%, E.
 8 JOURNAL OF PSYCHOLOGY, 1936, Provincetown,
 U.S.A., 3.5%.
 9 AMERICAN JOURNAL OF PSYCHOLOGY, 1887,
 Champaign, Ill., 3.3%, E.
 10 ACTA PSYCHIATRICA SCANDINAVICA, 1926,
 Copenhagen, Denmark, 3.2%, E.
 11 DISEASES OF THE NERVOUS SYSTEM, 1940, Memphis,
 Tenn., 3.2%, E.
 12 JOURNAL OF CLINICAL PSYCHOLOGY, 1945, Brandon,
 Vt., 3.0%, E.
 13 JOURNAL OF SOCIAL ISSUES, 1944, Ann Arbor,
 Mich., 2.9%, E.
 14 JOURNAL OF PSYCHOSOMATIC RESEARCH, 1956,
 Elmsford, N.Y. and Oxford, England, 2.9%, E.
 15 BEHAVIOR RESEARCH AND THERAPY, 1963, Elmsford,
 N.Y. and Oxford, England, 2.8%.
 16 BRITISH JOURNAL OF PSYCHOLOGY, 1904, Liecester,
 England, 2.7%, E.
 17 JOURNAL OF GENETIC PSYCHOLOGY, 1891,
 Provincetown, Mass., 2.7%, E.
 18 JOURNAL OF VERBAL LEARNING AND VERBAL BEHAVIOR,
 1962, New York, U.S.A., 2.6%, E.
 19 JOURNAL OF SOCIAL PSYCHOLOGY, 1929,
 Provincetown, U.S.A., 2.3%, E.
 20 JOURNAL OF APPLIED BEHAVIOR ANALYSIS, 1968,
 Lawrence, Kansas, 2.2%, E.
 21 SOCIOMETRY, 1937, New York, U.S.A., 2.2%, E.
 22 COGNITIVE PSYCHOLOGY, 1970, New York, U.S.A.,
 2.1%, E.
 23 HUMAN RELATIONS, 1947, New York, U.S.A., 2.0%,
 E.
 24 BEHAVIOR THERAPY, 1970, New York, U.S.A., 1.8%,
 E.
 25 JOURNAL OF EXPERIMENTAL SOCIAL PSYCHOLOGY,
 1965, New York, U.S.A., 1.6%, E.
 26 ADVANCES IN EXPERIMENTAL SOCIAL PSYCHOLOGY,*
 1964, New York, U.S.A., 1.2%, E.

R.F.

- 2:26:27 JOURNAL OF BEHAVIOR THERAPY AND EXPERIMENTAL
 PSYCHIATRY, 1970, Elmsford, N.Y. and Oxford,
 England, 0.8%, E.
 28 MEMORY AND COGNITION, 1973, Austin, Texas,
 0.8%, E.

Immunology and Allergies

- 2:27: 1 ARTHRITIS AND RHEUMATISM, 1958, Atlanta,
 Georgia, 6.5%, E.
 2 VIRCHOWS ARCHIV A: PATHOLOGICAL ANATOMY AND
 HISTORY, 1847, Berlin, West Germany and New
 York, U.S.A., 5.9%, E or G.
 3 JOURNAL OF INVESTIGATIVE DERMATOLOGY, 1938,
 Baltimore, Md., U.S.A., 5.7%, E.
 4 ISRAEL JOURNAL OF MEDICAL SCIENCES, 1965,
 Jerusalem, Israel, 5.6%, E.
 5 KIDNEY INTERNATIONAL, 1972, New York, U.S.A.,
 5.2%, E.
 6 ARCHIVES OF DERMATOLOGY, 1920, Chicago, Ill.,
 4.9%, E.
 7 ANNUAL REVIEW OF MEDICINE, 1950, Palo Alto,
 Cal., 4.5%, E.
 8 ADVANCES IN IMMUNOLOGY, 1961, New York, U.S.A.,
 4.4%, E.
 9 EXPERIMENTAL AND MOLECULAR PATHOLOGY, 1962,
 New York, U.S.A., 4.2%, E.
 10 JOURNAL OF ALLERGY AND CLINICAL IMMUNOLOGY,
 1929, St. Louis, Mo., 4.0%, E.
 11 JOURNAL OF PATHOLOGY, 1892, Edinburgh,
 Scotland, 3.8%, E.
 12 AUSTRALIAN JOURNAL OF EXPERIMENTAL BIOLOGY AND
 MEDICAL SCIENCES, 1924, Adelaide, Australia,
 3.8%, E.
 13 CLINICAL IMMUNOLOGY AND IMMUNOPATHOLOGY, 1972,
 New York, U.S.A., 3.8%, E.
 14 ANNALS OF THE RHEUMATIC DISEASES, 1939, London,
 England, 3.5%, E.
 15 SCANDINAVIAN JOURNAL OF IMMUNOLOGY, 1972,
 Oxford, England, 3.5%, E.
 16 BRITISH JOURNAL OF DERMATOLOGY, 1886, Oxford,
 England, 3.5%, E.
 17 VOX SANGUINS, 1951, Journal of Blood Trans-
 fusion, Immunohaematology and Immunopathology,
 Basel, Switzerland, 3.4%, E.
 18 ATHEROSCLEROSIS, 1961, Limerick, Ireland, 3.1%,
 E, F, G.
 19 HUMAN PATHOLOGY, 1970, Philadelphia, Pa., 3.0%,
 E.
 20 JOURNAL OF IMMUNOLOGICAL METHODS, 1971,
 Amsterdam, Netherlands, 3.0%, E.
 21 NEPHRON, 1964, Basel, Switzerland, 2.8%, E.
 22 PROGRESS IN ALLERGY, 1939, Basel, Switzerland,
 2.6%, E.
 23 BEITRAEGE ZUR PATHOLOGIE, 1886, Stuttgart,
 West Germany, 2.0%, E, F, G.
 24 TISSUE ANTIGENS, 1971, Copenhagen, Denmark,
 1.8%, E.
 25 ACTA DERMATO-VENEREOLOGICA, 1920, Stockholm,
 Sweden, 1.4%, E.
 26 TRANSFUSION, 1961, Philadelphia, U.S.A., 1.2%,
 E.
 27 IMMUNOGENETICS, 1974, New York, U.S.A., 1.0%,
 E.
 28 DERMATOLOGICA, 1893, Basel, Switzerland, 0.9%,
 E, F, G.
 29 CLINICAL ALLERGY, 1971, Oxford, England, 0.9%,
 E.

Main Economics

- 10:28: 1 AMERICAN ECONOMIC REVIEW, 1911, Nashville,
 Tenn., 22.4%, E.
 2 JOURNAL OF POLITICAL ECONOMY, 1892, Chicago,
 Ill., 10.9%, E.

LIST OF JOURNALS IN EACH FRONT - Continued

R.F.

Main Economics - Concluded

- 10:28: 3 ECONOMETRICA, 1933, Evanston, Ill., 12.0%, E.
 4 REVIEW OF ECONOMICS AND STATISTICS, 1976,
 Amsterdam, Netherlands, 11.9%, E.
 5 QUARTERLY JOURNAL OF ECONOMICS, 1886, New York,
 U.S.A., 9.9%, E.
 6 ECONOMIC JOURNAL, 1891, Cambridge, England,
 8.0%, E.
 7 REVIEW OF ECONOMIC STUDIES, 1933, Edinburgh,
 Scotland, 7.9%, E.
 8 ECONOMICA, 1921, London, England, 4.2%, E.
 9 JOURNAL OF ECONOMIC THEORY, 1969, New York,
 U.S.A., 3.5%, E.
 10 INTERNATIONAL ECONOMIC REVIEW, 1960,
 Philadelphia, Pa., 3.1%, E.

Plant Biology and Soil Science

- 5:29: 1 AUSTRALIAN JOURNAL OF BIOLOGICAL SCIENCES,
 1948, Melbourne, Australia, 12.7%, E.
 2 PHYTOPATHOLOGY, 1911, St. Paul, Minn., 9.4%.
 3 PROTOPLASMA, 1926, New York, U.S.A. and Vienna,
 Austria, 8.7%, E, F, G.
 4 CROP SCIENCE, 1961, Madison, Wisc., 6.8%, E.
 5 SOIL SCIENCE, 1916, Baltimore, U.S.A., 6.5%, E.
 6 ANNALS OF APPLIED BIOLOGY, 1914, Warwick,
 England, 6.1%, E.
 7 AGRONOMY JOURNAL, 1907, Madison, Wisc., 6.1%,
 E.
 8 SOIL SCIENCE SOCIETY OF AMERICA, JOURNAL, 1936,
 Madison, Wisc., 5.8%, E.
 9 BOTANICAL GAZETTE, 1875, Chicago, Ill., 5.2%,
 E.
 10 PLANT AND SOIL, 1949, The Hague, Netherlands,
 4.8%, E, F, G.
 11 BOTANICAL REVIEW, 1935, Bronx, N.Y., 4.7%, E.
 12 CYTOBIOLOGIE, 1969, Stuttgart, West Germany,
 4.0%, E, F, G, summaries in E.
 13 MYCOLOGIA, 1909, Bronx, N.Y., 3.1%, E.
 14 ANNUAL REVIEW OF PHYTOPATHOLOGY, 1963,
 Palo Alto, Cal., 2.9%, E.
 15 CANADIAN JOURNAL OF PLANT SCIENCE, 1921,
 Ottawa, Canada, 2.7%, E, F.
 16 BRITISH MYCOLOGICAL SOCIETY, TRANSACTIONS,
 1896, London, England, 2.7%, E.
 17 PLANT DISEASE REPORTER, 1970, Hyattsville, Mo.,
 2.6%, E.
 18 SOIL BIOLOGY AND BIOCHEMISTRY, 1969, Elmsford,
 N.Y. and Oxford, England, 2.1%, E.
 19 JOURNAL OF SOIL SCIENCE, 1949, London, England,
 1.9%, E.
 20 PHYTOPATHOLOGISCHE ZEITSCHRIFT/JOURNAL OF
 PHYTOPATHOLOGY, 1930, Berlin, West Germany,
 1.4%, E, F, G, I, summaries in E, G.

Applied Mathematics, Secondary Physical
Applications

- 6:30: 1 PHYSICS OF FLUIDS, 1958, New York, U.S.A.,
 12.5%, E.
 2 NUCLEAR INSTRUMENTS AND METHODS, 1957,
 Amsterdam, Netherlands, 10.9%, E, F, G,
 summaries in E.
 3 JOURNAL OF FLUID MECHANICS, 1956, Cambridge,
 England, 7.0%, E.
 4 COMMUNICATIONS ON PURE AND APPLIED MATHEMATICS,
 1939, New York, U.S.A., 4.7%, E.
 5 LONDON MATHEMATICAL SOCIETY, PROCEEDINGS, 1865,
 London, England, 4.7%, E.
 6 ARCHIVE FOR RATIONAL MECHANICS AND ANALYSIS,
 1957, New York, U.S.A., 4.4%, E, F, G, I,
 Latin.
 7 JOURNAL OF APPLIED MECHANICS, 1935, New York,
 U.S.A., 4.2%, E.
 8 JOURNAL OF MATHEMATICAL ANALYSIS AND
 APPLICATIONS, 1960, New York, U.S.A., 4.1%, E.

R.F.

- 6:30: 9 LONDON MATHEMATICAL SOCIETY, JOURNAL, 1926,
 London, England, 3.3%, E.
 10 A.I.A.A. JOURNAL, 1963, New York, U.S.A., 3.2%,
 E.
 11 JOURNAL OF FUNCTIONAL ANALYSIS, 1967, New York,
 U.S.A., 3.1%, E, F.
 12 ACADEMIE DES SCIENCES, COMPTES RENDUS
 HEBDOMADAIRES DES SEANCES, SERIES A: SCIENCES
 MATHÉMATIQUES, 1835, Cedex, France, 3.0%, F.
 13 JOURNAL FÜR DIE REINE UND ANGEWANDTE
 MATHEMATIK, 1826, Berlin, West Germany, 2.9%,
 E, F, G.
 14 I.E.E.E. TRANSACTIONS, NUCLEAR SCIENCE, 1954,
 Piscataway, N.J., 2.9%, E.
 15 JOURNAL OF ALGEBRA, 1964, New York, U.S.A.,
 2.7%, E.
 16 NUCLEAR FUSION/FUSION NUCLEAIRE, 1960, Vienna,
 Austria, 2.4%, E, F, summaries in E, F.
 17 STUDIA UNIVERSITATIS "BABES-BOLVAI"
 MATHEMATICA, 1958, Cluj-Napoca, Romania, 2.4%,
 Romanian, summaries in E, F, G, R.
 18 INVENTIONES MATHEMATICAE, 1966, New York,
 U.S.A., 2.4%, E, F, G.
 19 TOPOLOGY, 1962, Elmsford, N.Y. and Oxford,
 England, 2.3%, E, F, G, I.
 20 S.I.A.M. JOURNAL ON APPLIED MATHEMATICS, 1953,
 Philadelphia, Pa., 2.3%, E.
 21 ILLINOIS JOURNAL OF MATHEMATICS, 1957,
 Champaign, Ill., 2.2%, E, F, G, I.
 22 QUARTERLY OF APPLIED MATHEMATICS, 1943,
 Providence, R.I., 2.2%, E.
 23 ISRAEL JOURNAL OF MATHEMATICS, 1951, Jerusalem,
 Israel, 1.9%, E.
 24 JOURNAL OF THE MECHANICS AND PHYSICS OF SOLIDS,
 1952, Elmsford, N.Y. and Oxford, England, 2.9%,
 E.
 25 PLASMA PHYSICS, 1959, Elmsford, N.Y. and
 Oxford, England, 1.8%, E, F, G.
 26 JOURNAL OF SOUND AND VIBRATION, 1964, London,
 England, 1.2%, E.
 27 INTERNATIONAL JOURNAL OF SOLIDS AND STRUCTURES,
 1965, Elmsford, N.Y. and Oxford, England, 1.1%,
 E.
 28 INTERNATIONAL JOURNAL OF FRACTURE, 1965, Alphen
 aan den Rijn, Netherlands, 0.8%, E, F, G.
 29 JOURNAL OF PLASMA PHYSICS, 1967, Cambridge,
 England, 0.8%, E.
 30 ENGINEERING FRACTURE MECHANICS, 1968, Elmsford,
 N.Y. and Oxford, England, 0.6%, E, summaries E,
 G.

Secondary Geophysics and Space Science

- 9:31: 1 PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY
 OF LONDON, SERIES A, MATHEMATICAL AND PHYSICAL
 SCIENCES, 1665, 23.4%, E.
 2 REVIEWS OF GEOPHYSICS AND SPACE PHYSICS, 1963,
 Washington, D.C., 11.2%, E.
 3 EOS, TRANSACTIONS OF THE AMERICAN GEOPHYSICAL
 UNION, 1919, Washington, D.C., 9.2%, E.
 4 PLANETARY AND SPACE SCIENCE, 1959, Elmsford,
 N.Y. and Oxford, England, 7.7%, E.
 5 GEOPHYSICAL RESEARCH LETTERS, 1974,
 Washington, D.C., 6.6%, E.
 6 ICARUS, 1962, New York, U.S.A., 6.1%, E.
 7 TECTONOPHYSICS, 1964, Amsterdam, Netherlands,
 6.0%, E, F, G.
 8 JOURNAL OF ATMOSPHERIC AND TERRESTRIAL PHYSICS,
 1950, Elmsford, N.Y. and Oxford, England, 4.9%,
 E.
 9 GEOLOGY, 1973, Boulder, Col., 4.7%, E.
 10 RADIO SERVICE, 1969, Washington, D.C., 4.5%, E.
 11 SPACE SCIENCE REVIEWS, 1962, Dordrecht,
 Netherlands, 4.1%, E, F, G, R.
 12 PHYSICS OF THE EARTH AND PLANETARY INTERIORS,
 1967, Amsterdam, Netherlands, 3.3%, E.
 13 J.G.R.: JOURNAL OF GEOPHYSICAL RESEARCH A:
 SPACE PHYSICS, 1909, Washington, D.C., 3.1%, E.

LIST OF JOURNALS IN EACH FRONT - Continued

R.F.

Secondary Geophysics and Space Science -
Concluded

- 9:31:14 ANNALES DE GEOPHYSIQUE, 1945, Paris, France,
2.8%, E, F, G, summaries in E.
15 GEOPHYSICS, 1936, Tulsa, Okla., 2.4%, E.

Secondary Microbiology, Veterinary Science

- 2:32: 1 AMERICAN JOURNAL OF VETERINARY RESEARCH, 1940,
Schaumburg, Ill., 14.9%, E.
2 JOURNAL OF HYGIENE, 1901, Cambridge, Mass.,
12.1%, E.
3 ZENTRALBLATT DER BAKTERIOLOGIE,
PARASITENKUNDE, INFESTIONSKRANKHEITEN UND
HYGIENE, 1887, Stuttgart, West Germany, 10.2%,
G, summaries in E, G.
4 AMERICAN VETERINARY MEDICAL ASSOCIATION,
JOURNAL, 1869, Schaumburg, Ill., 8.9%, E.
5 VETERINARY RECORD, 1888, London, England, 8.3%,
E.
6 RESEARCH IN VETERINARY SCIENCE, 1960, London,
England, 7.0%, E.
7 JOURNAL OF MEDICAL MICROBIOLOGY, 1968,
Edinburgh, Scotland, 6.7%, E.
8 ACTA PATHOLOGICA ET MICROBIOLOGICA
SCANDINAVICA, SECTION B: MICROBIOLOGY, 1924,
Copenhagen, Denmark, 6.6%, E, F, G.
9 JOURNAL OF CLINICAL MICROBIOLOGY, 1975,
Washington, D.C., 5.0%, E.
10 JOURNAL OF COMPARATIVE PATHOLOGY, 1888, London,
England, 4.8%, E.
11 AUSTRALIAN VETERINARY ASSOCIATION, JOURNAL,
1926, Melbourne, Australia, 4.0%, E.
12 BRITISH VETERINARY JOURNAL, 1875, London,
England, 3.7%, E.
13 CORNELL VETERINARIAN, 1911, Ithaca, N.Y., 3.2%,
E.
14 CANADIAN JOURNAL OF COMPARATIVE MEDICINE/REVUE
CANADIENNE DE MEDICINE COMPAREE, 1937, Ottawa,
Canada, 2.6%, E, F.
15 AVIAN DISEASES, 1957, Texas, U.S.A., 2.1%, E.

Secondary Law

- 16:33: 1 MINN LAW REV
2 VANDERBILT LAW REV
3 LAW CONTEMP PROBL
4 AM BAR ASSOC J
5 DUKE LAW J
6 UCLA LAW REV
7 NORTHWEST U LAW REV
8 SOUTHERN CALIF LAW R
9 GEORGETOWN LAW J
10 IOWA LAW REV
11 WISC LAW REV
12 HASTINGS LAW J
13 BUS LAWYER
14 GEORGE WASH LAW REV
15 SUPREME COURT REV

Chemical Engineering

- 7:34: 1 ZEITSCHRIFT FUER PHYSIKALISCHE CHEMIE, 1954,
Frankfurt Am Main, West Germany, 5.2%, E, G.
2 A.I.C.H.E. JOURNAL, 1955, New York, U.S.A.,
4.9%, E.
3 BULLETIN DES SOCIETES CHIMIQUES BELGES, 1887,
Brussels, Belgium, 4.8%, Dutch, F, E.
4 JOURNAL OF CHEMICAL AND ENGINEERING DATA, 1959,
Washington, D.C., 4.6%, E.
5 STRUCTURE AND BONDING, 1971, New York, U.S.A.,
4.4%, E.

R.F.

- 7:34: 6 YAKUGAKU ZASSHI/PHARMACEUTICAL SOCIETY OF
JAPAN, 1970, Osaka, Japan, 4.4%, J, summaries
in E.
7 ADVANCES IN INORGANIC CHEMISTRY AND
RADIOCHEMISTRY, 1959, New York, U.S.A., 4.3%,
E.
8 INDIAN CHEMICAL SOCIETY, JOURNAL, 1924,
Calcutta, India, 4.2%, E.
9 ISRAEL JOURNAL OF CHEMISTRY, 1951, Jerusalem,
Israel, 3.6%, E.
10 ANNALI DI CHIMICA, 1970, Rome, Italy, 3.6%, E,
I.
11 ROCZNIKI CHEMII, 1921, Warsaw, Poland, 3.6%,
various languages.
12 PROGRESS IN INORGANIC CHEMISTRY,* 1959,
New York, U.S.A., 3.4%, E.
13 ORGANIC REACTIONS,* 1942, New York, U.S.A.,
3.4%, E.
14 CHEMICAL SOCIETY, LONDON, REVIEWS, 1972,
London, England, 3.4%, E.
15 ACTA CHIMICA, 1951, Budapest, Hungary, 3.4%, E,
F, G, R.
16 CHIMIA, 1947, Zurich, Switzerland, 3.3%, E, F,
G.
17 CHEMICAL ENGINEERING SCIENCE/JOURNAL
INTERNATIONAL DE GENIE CHIMIQUE, 1951,
Elmsford, N.Y. and Oxford, England, 3.2%, E,
F, G.
18 JOURNAL OF CHEMICAL THERMODYNAMICS, 1969,
New York, U.S.A., 3.0%, E.
19 ADVANCES IN CATALYSIS AND RELATED SUBJECTS,
1948, New York, U.S.A., 2.8%, E.
20 INDUSTRIAL AND ENGINEERING CHEMISTRY
FUNDAMENTALS, 1962, Washington, D.C., 2.7%, E.
21 ZEITSCHRIFT FUER PHYSIKALISCHE CHEMIE, 1943,
Leipzig, East Germany, 2.6%, E, G.
22 ARCHIV DER PHARMAZIE, 1822, Weinheim,
West Germany, 2.4%, G.
23 CHEMIE-INGENIEUR-TECHNIK, 1949, West Germany
and Deerfield Beach, Fla., 2.3%, E, G.
24 ADVANCES IN PHYSICAL ORGANIC CHEMISTRY, 1963,
London, England, 2.2%, E.
25 PROGRESS IN PHYSICAL ORGANIC CHEMISTRY,* 1963,
New York, U.S.A., 2.1%, E.
26 ADVANCES IN ORGANOMETALLIC CHEMISTRY, 1964,
New York, U.S.A., 2.1%, E.
27 ACADEMIE POLONAISE DES SCIENCES, BULLETIN,
SERIE DES SCIENCES CHIMIQUES, 1953, Warsaw,
Poland, 2.0%, various languages.
28 ADVANCES IN HETEROCYCLIC CHEMISTRY, 1972,
New York, U.S.A., 1.9%, E.
29 TOPICS IN STEREOCHEMISTRY,* 1967, New York,
U.S.A., 1.9%, E.
30 DIE PHARMAZIE, 1946, Berlin, East Germany,
1.7%, E, F, G.
31 INTERNATIONAL JOURNAL OF HEAT AND MASS
TRANSFER, 1960, Elmsford, N.Y. and Oxford,
England, 1.6%, E.
32 CANADIAN JOURNAL OF CHEMICAL ENGINEERING/
JOURNAL CANADIEN DE CHIMIE INGENIEUR, 1929,
Ottawa, Canada, 1.6%, E, F.
33 CHEMICAL ENGINEERING, 1902, New York, U.S.A.,
1.5%, E.
34 SYNTHETIC COMMUNICATIONS, 1971, New York,
U.S.A., 1.5%, E.
35 CHEMICAL ENGINEERING PROGRESS (CEP), 1947,
New York, U.S.A., 1.5%, E.
36 INDUSTRIAL AND ENGINEERING CHEMISTRY PROCESS
DESIGN AND DEVELOPMENT, 1962, Washington, D.C.,
1.4%, E.
37 HETEROCYCLES, 1973, Sendai, Japan, 1.2%, E.
38 CATALYSIS REVIEWS: SCIENCE AND ENGINEERING,
1967, New York, U.S.A., 1.2%.
39 JOURNAL OF HEAT TRANSFER, 1970, New York,
U.S.A., 0.7%, E.
40 INSTITUTION OF CHEMICAL ENGINEERS,
TRANSACTIONS, Rugby, England, 0.7%, E.

LIST OF JOURNALS IN EACH FRONT - Continued

R.F.

Chemical Engineering - Concluded

- 7:34:41 HYDROCARBON PROCESSING, 1922, Houston, Texas, 0.7%, F.

Dentistry

- 15:35: 1 JOURNAL OF DENTAL RESEARCH, 1919, Houston, Texas, 21.2%, E.
 2 ARCHIVES OF ORAL BIOLOGY, 1959, Elmsford, N.Y. and Oxford, England, 19.2%, E, F, G.
 3 ORAL SURGERY, ORAL MEDICINE AND ORAL PATHOLOGY, 1948, St. Louis, Mo., 13.7%, E.
 4 AMERICAN DENTAL ASSOCIATION, JOURNAL, 1913, Chicago, Ill., 10.4%, E.
 5 BRITISH DENTAL JOURNAL, 1880, London, England, 7.8%, E.
 6 JOURNAL OF PERIODONTOLOGY, 1930, Chicago, Ill., 6.2%, E.
 7 JOURNAL OF ORAL SURGERY, 1943, Chicago, Ill., 5.5%, E.
 8 ACTA ODONTOLOGICA SCANDINAVICA, 1942, Oslo, Norway, 4.6%, E.
 9 JOURNAL OF PERIODONTAL RESEARCH, 1966, Copenhagen, Denmark, 2.7%, E.
 10 CARIES RESEARCH, 1967, Basel, Switzerland, 2.6%, E.
 11 JOURNAL OF PROSTHETIC DENTISTRY, 1951, St. Louis, Mo., 2.5%, E.

General Clinical Medicine

- 2:36: 1 ACADEMIE DES SCIENCES, COMPTES RENDUS HEBDOMADAIRES DES SEANCES, SERIES D: SCIENCES NATURELLES, 1835, Montreuil, France, 6.8%, F.
 2 SOCIETE DE BIOLOGIE ET DE SES FILIALES, COMPTES RENDUS DES SEANCES, 1849, Paris, France, 5.2%, F.
 3 RADIATION RESEARCH, 1954, New York, U.S.A., 4.6%, E.
 4 JOURNAL OF GENERAL VIROLOGY, 1967, Cambridge, England, 3.5%, E.
 5 ADVANCES IN CANCER RESEARCH, 1972, New York, U.S.A., 3.5%, E.
 6 GENERAL AND COMPARATIVE ENDOCRINOLOGY, 1961, New York, U.S.A., 3.4%, E.
 7 EUROPEAN JOURNAL OF CANCER, 1965, Elmsford, N.Y. and Oxford, England, 3.2%, E.
 8 SCANDINAVIAN JOURNAL OF GASTROENTEROLOGY, 1966, Oslo, Norway, 3.1%, E.
 9 NEW YORK STATE JOURNAL OF MEDICINE, 1901, Lake Success, N.Y., 3.1%, E.
 10 CARDIOVASCULAR RESEARCH, 1967, London, England, 3.1%, E.
 11 PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR CANCER RESEARCH, 1924, Baltimore, U.S.A., 2.8%, E.
 12 PROGRESS IN CARDIOVASCULAR DISEASES, 1958, New York, U.S.A., 2.5%, E.
 13 JOURNAL OF MOLECULAR AND CELLULAR CARDIOLOGY, 1970, New York, U.S.A., 2.4%, E.
 14 LA NOUVELLE PRESSE MEDICALE, 1893, Paris, France, 2.3%, F, summaries in E.
 15 POSTGRADUATE MEDICINE, 1947, Minneapolis, Minn., 2.3%, E.
 16 CELL AND TISSUE KINETICS, 1968, Oxford, England, 2.1%, E.
 17 NEW YORK ACADEMY OF MEDICINE, BULLETIN, 1925, New York, U.S.A., 2.1%, E.
 18 PEDIATRIC CLINICS OF NORTH AMERICA, 1954, Philadelphia, Pa., 2.1%, E.
 19 DIGESTION, 1968, Basel, Switzerland, 2.0%, E.
 20 AMERICAN JOURNAL OF GASTROENTEROLOGY, 1934, New York, U.S.A., 1.9%, E.
 21 IN VITRO, 1965, Gaithersburg, Mo., 1.8%, E.
 22 JOURNAL OF CANCER RESEARCH AND CLINICAL ONCOLOGY (FORMERLY ZEITSCHRIFT FÜR KREBSFORSCHUNG UND

R.F.

- 2:36:22 KLINISCHE ONKOLOGIE), 1903, Berlin, West Germany, and New York, U.S.A., 1.8%, E, F, G, summaries in E.
 23 ADVANCES IN NEUROLOGICAL SCIENCES/SHINKEI KENKYU NO SHINPO, 1966, Tokyo, Japan, 1.8%, J, summaries in E, various languages.
 24 JOURNAL OF PHYSIOLOGIE, 1899, Paris, France, 1.7%, summaries in E, F.
 25 CLINICAL RADIOLOGY, 1950, Edinburgh, Scotland, 1.7%, E.
 26 ADVANCES IN BIOCHEMICAL PSYCHOPHARMACOLOGY,* 1969, New York, U.S.A., 1.6%, E.
 27 NATIONAL CANCER INSTITUTE MONOGRAPHS, 1959, Bethesda, Md., 1.6%, E.
 28 REVUE NEUROLOGIQUE, 1893, Paris, France, 1.6%, F, summaries in E.
 29 SEMAINE DES HOPITAUX, 1925, Paris, France, 1.6%, F, summaries in E.
 30 CHEMICO-BIOLOGICAL INTERACTIONS, 1969, Limerick, Ireland, 1.5%, E.
 31 EPILEPSIA, 1959, New York, U.S.A., 1.5%, E, F, G, summaries in E, F, G, Sp.
 32 INTERNATIONAL JOURNAL OF RADIATION BIOLOGY, 1959, London, England, 1.5%, E, F, G.
 33 GANN JOURNAL/GAN (CANCER), 1907, Tokyo, Japan, 1.5%, E and European languages, summaries in E.
 34 CLINICAL PEDIATRICS, 1962, Philadelphia, Pa., 1.3%, E.
 35 JOURNAL OF NEUROBIOLOGY, 1969, New York, U.S.A., 1.3%, E.
 36 DISEASES OF THE COLON AND RECTUM, 1958, Philadelphia, Pa., 1.3%, E.
 37 JAPANESE JOURNAL OF PHYSIOLOGY, 1947, Tokyo, Japan, 1.2%, J.
 38 INTERNATIONAL REVIEW OF NEUROBIOLOGY, 1959, New York, U.S.A., 1.2%, E.
 39 MICROVASCULAR RESEARCH, 1968, New York, U.S.A., 1.1%, E.
 40 ARCHIVES FRANCAISES DE PEDIATRIE, 1942, Paris, France, 1.0%, F, summaries in E.
 41 HELVETICA PAEDIATRICA ACTA, 1945, Basel, Switzerland, 1.0%, E, F, G, summaries in original language and E.
 42 INVESTIGATIVE RADIOLOGY, 1966, Philadelphia, Pa., 1.0%, E.
 43 ARCHIVES ITALIENNES DE BIOLOGIE, 1882, Pisa, Italy, 1.0%, E, F.
 44 CLINICS IN GASTROENTEROLOGY, 1972, Philadelphia, Pa., 0.9%, E.
 45 JOURNAL OF NEUROCYTOLOGY, 1972, London, England, 0.9%, E.
 46 ACTA RADIOLOGICA SERIES 1: DIAGNOSIS, 1921, Stockholm, Sweden, 0.9%, E.
 47 JOURNAL OF NEURAL TRANSMISSION, 1950, New York, U.S.A., 0.8%, E, F, G.
 48 RADIOLOGIC CLINICS IN NORTH AMERICA, 1963, Philadelphia, Pa., 0.8%, E.
 49 BRAIN, BEHAVIOR AND EVOLUTION, 1968, Basel, Switzerland, 0.7%, E.
 50 GASTROINTESTINAL ENDOSCOPY, 1953, Boston, Mass., 0.4%, E.
 51 ANNALS OF CLINICAL RESEARCH, 1969, Helsinki, Finland, 0.4%, E.
 52 NEURORADIOLOGY, 1970, New York, U.S.A., 0.4%, E.
 53 REVUE DU RHUMATISME ET DES MALADIES OSTEOARTICULAIRES, 1933, Paris, France, 0.4%, summaries in E, G, Sp.
 54 ENDOSCOPY, 1969, Stuttgart, West Germany, 0.3%, E, G, summaries in E.

Laryngology and Plastic Surgery

- 13:37: 1 ARCHIVES OF OTOLARYNGOLOGY, 1925, Chicago, Ill., 21.0%, E.
 2 ANNALS OF OTOTOLOGY, RHINOLOGY AND LARYNGOLOGY, 1892, St. Louis, Mo., 20.3%, E.

LIST OF JOURNALS IN EACH FRONT - Continued

R.F.

Laryngology and Plastic Surgery - Concluded

- 13:37: 3 LARYNGOSCOPE, 1896, St. Louis, Mo., 15.5%, E.
 4 ACTA OTO-LARYNGOLOGICA, 1919, Stockholm, Sweden, 14.7%, E.
 5 PLASTIC AND RECONSTRUCTIVE SURGERY, 1946, Baltimore, U.S.A., 12.6%, E.
 6 JOURNAL OF LARYNGOLOGY AND OTOTOLOGY, 1887, Ashford, England, 10.1%, E.
 7 BRITISH JOURNAL OF PLASTIC SURGERY, 1948, Edinburgh, Scotland, 5.8%, E.

Animal Biology

- 10:38: 1 SCIENTIFIC AMERICAN, 1845, New York, U.S.A., 14.5%, E.
 2 ANIMAL BEHAVIOR, 1953, London, England, 9.0%, E.
 3 QUARTERLY REVIEW OF BIOLOGY, 1926, Stoney Brook, N.Y., 7.0%, E.
 4 AMERICAN SCIENTIST, 1913, New Haven, Conn., 6.8%, E.
 5 PHARMACOLOGY, BIOCHEMISTRY AND BEHAVIOR, 1973, Fayetteville, N.Y., 6.6%, E.
 6 BEHAVIOR, AN INTERNATIONAL JOURNAL OF COMPARATIVE ETHOLOGY, 1947, Leiden, Netherlands, 5.5%, E.
 7 JOURNAL OF ZOOLOGY, 1830, London, England, 5.3%, E.
 8 BEHAVIORAL BIOLOGY, 1968, New York, U.S.A., 5.3%, E.
 9 ECOLOGIA, 1924, Berlin, West Germany, 4.8%, E, F, G.
 10 OIKOS, 1948, Copenhagen, Denmark, 4.2%, E.
 11 JOURNAL OF APPLIED ECOLOGY, 1964, Oxford, England, 3.6%, E.
 12 ANNUAL REVIEW OF ECOLOGY AND SYSTEMATICS, 1970, Palo Alto, Cal., 3.5%, E.
 13 CONDOR, 1899, Lebranon, N.H., 3.0%, E.
 14 ZEITSCHRIFT FUER TIERPSYCHOLOGIE/JOURNAL OF COMPARATIVE ETHOLOGY, 1937, Berlin, West Germany, 3.0%, E.
 15 AUK, 1884, Chicago, Ill., 2.8%, E.
 16 ARCHIV FUER HYDROBIOLOGIE, 1906, Stuttgart, West Germany, 2.7%, E, F, G.
 17 HORMONES AND BEHAVIOR, 1969, New York, U.S.A., 2.6%, E.
 18 JOURNAL OF WILDLIFE MANAGEMENT, 1937, Washington, D.C., 2.5%, E.
 19 HYDROBIOLOGICA (ARTIA HYDROBIOLOGICA, HYDROGRAPHICA ET PROTESTOLOGICA), 1948, The Hague, Netherlands, 2.4%, E, F, G.
 20 I.B.I.S., 1969, Chicago, Ill., 2.2%, E.
 21 WILSON BULLETIN, 1889, Toronto, Canada, 1.5%, E.
 22 FRESHWATER BIOLOGY, 1971, Oxford, England, 1.1%, E.

Applied Microbiology, Biotechnology

- 2:39: 1 CARBOHYDRATE RESEARCH, 1965, Amsterdam, Netherlands, 10.2%, E, F, G.
 2 LIPIDS, 1966, Champaign, Ill., 9.5%, E.
 3 AGRICULTURAL AND BIOLOGICAL CHEMISTRY JOURNAL, 1924, Tokyo, Japan, 9.2%, E, F, G.
 4 ADVANCES IN EXPERIMENTAL MEDICINE AND BIOLOGY,* 1967, New York, U.S.A., 7.6%, E.
 5 BIOCHEMICAL MEDICINE, 1968, New York, U.S.A., 6.6%, E.
 6 YALE JOURNAL OF BIOLOGY AND MEDICINE, 1928, New Haven, U.S.A., 6.1%, E.
 7 JOURNAL OF ANTIBIOTICS, 1947, Tokyo, Japan, 5.9%, E.
 8 AMERICAN OIL CHEMISTS, SOCIETY, JOURNAL, 1917, Chicago, Ill., 5.5%, E.

R.F.

- 2:39: 9 ARCHIVES INTERNATIONALES DE PHYSIOLOGIE ET DE BIOCHIMIE, 1904, Paris, France, 4.9%, E, F.
 10 ADVANCES IN ENZYME REGULATION, 1963, Elmsford, N.Y., 4.8%, E.
 11 VITAMINS AND HORMONES: ADVANCES IN RESEARCH AND APPLICATIONS, 1943, New York, U.S.A., 4.3%, E.
 12 BIOTECHNOLOGY AND BIOENGINEERING, 1958, New York, U.S.A., 3.3%, E.
 13 MOLECULAR AND CELLULAR ENDOCRINOLOGY, 1974, Limerick, Ireland, 3.3%, E.
 14 INTERNATIONAL JOURNAL OF BIOCHEMISTRY, 1970, Elmsford, N.Y. and Oxford, England, 3.1%, E.
 15 CURRENT TOPICS IN CELLULAR REGULATION, 1969, New York, U.S.A., 3.1%, E.
 16 BROOKHAVEN SYMPOSIA IN BIOLOGY, 1952, Springfield, Va., 2.9%, E.
 17 ADVANCES IN CARBOHYDRATE CHEMISTRY AND BIOCHEMISTRY, 1972, New York, U.S.A., 2.4%, E.
 18 JOURNAL OF APPLIED BACTERIOLOGY, 1938, London, England, 2.4%, E.
 19 MOLECULAR AND CELLULAR BIOCHEMISTRY, 1973, The Hague, Netherlands, 2.4%, E, F, G.
 20 ENDOCRINOLOGIA JAPANICA, 1954, Tokyo, Japan, 2.3%, E, F, G.
 21 INTERNATIONAL JOURNAL OF SYSTEMATIC BACTERIOLOGY, 1951, Washington, D.C., 2.2%, E.
 22 ANTONIE VAN LEEUWENHOEK JOURNAL OF MICROBIOLOGY, 1935, Delft, Netherlands, 1.6%, E.
 23 ADVANCES IN MICROBIAL PHYSIOLOGY, 1967, New York, U.S.A., 1.3%, E.
 24 JOURNAL OF GENERAL AND APPLIED MICROBIOLOGY, 1973, Tokyo, Japan, 1.1%, E.
 25 AGRICULTURAL CHEMICAL SOCIETY OF JAPAN, JOURNAL, 1924, Tokyo, Japan, 1.8%, J, content page in E.
 26 JOURNAL OF FERMENTATION TECHNOLOGY, 1925, Osaka, Japan, 0.7%, E.

Behavioural Sciences

- 2:40: 1 AMERICAN SOCIOLOGICAL REVIEW, 1936, Washington, D.C., 14.6%, E.
 2 AMERICAN JOURNAL OF SOCIOLOGY, 1895, Chicago, Ill., 11.7%, E.
 3 JOURNAL OF EDUCATIONAL PSYCHOLOGY, 1910, Washington, D.C., 10.0%, E.
 4 JOURNAL OF APPLIED PSYCHOLOGY, 1917, Washington, D.C., 7.6%, E.
 5 SOCIAL FORCES, 1922, Chapel Hill, N.C., 6.4%, E.
 6 SOCIAL PROBLEMS, 1953, Buffalo, N.Y., 5.1%, E.
 7 PUBLIC OPINION QUARTERLY, 1937, New York, U.S.A., 4.8%, E.
 8 JOURNAL OF EXPERIMENTAL CHILD PSYCHOLOGY, 1964, New York, U.S.A., 4.7%, E.
 9 AMERICAN POLITICAL SCIENCE REVIEW, 1906, Washington, D.C., 4.6%, E.
 10 ADMINISTRATIVE SCIENCE QUARTERLY, 1956, Ithaca, N.Y., 4.0%, E.
 11 JOURNAL OF CRIMINAL LAW AND CRIMINOLOGY, 1910, Baltimore, Md., 3.9%, E.
 12 JOURNAL OF MARRIAGE AND THE FAMILY, 1939, Minneapolis, Minn., 3.7%, E.
 13 HARVARD EDUCATIONAL REVIEW, 1931, Cambridge, Mass., 3.7%, E.
 14 ORGANIZATIONAL BEHAVIOR AND HUMAN PERFORMANCE, 1966, New York, U.S.A., 3.5%, E.
 15 REVIEW OF EDUCATIONAL RESEARCH, 1931, Washington, D.C., 3.0%, E.
 16 AMERICAN EDUCATIONAL RESEARCH JOURNAL, 1964, Washington, D.C., 2.8%, E.
 17 JOURNAL OF EDUCATIONAL RESEARCH, 1920, Washington, D.C., 2.5%, E.
 18 PERSONNEL PSYCHOLOGY, 1948, Durham, N.C., 1.7%, E.

LIST OF JOURNALS IN EACH FRONT - Continued

R.F.

Behavioural Sciences - Concluded

- 2:40:19 JOURNAL OF POLITICAL AND MILITARY SOCIOLOGY, 1974, New Brunswick, N.J., 1.5%, E.

Photo-chemistry, Applied Physics

- 7:41: 1 ORGANIC MASS SPECTROMETRY, 1968, London, England, 7.3%, E.
 2 MOLECULAR CRYSTALS AND LIQUID CRYSTALS, LETTERS, 1966, London, England, 6.9%, E.
 3 APPLIED PHYSICS, 1973, West Germany, 6.9%, E.
 4 U.S. NATIONAL BUREAU OF STANDARDS, SECTION A: PHYSICS AND CHEMISTRY, 1959, Washington, D.C., 6.5%, E.
 5 I.B.M. JOURNAL OF RESEARCH AND DEVELOPMENT, 1957, Armonk, N.Y., 6.2%, E.
 6 PHILIPS RESEARCH REPORTS, 1945, Eindhoven, Netherlands, 5.5%, E.
 7 INTERNATIONAL JOURNAL OF MASS SPECTROMETRY AND ION PHYSICS, 1968, Amsterdam, Netherlands, 5.1%, E, F, G.
 8 RADIATION EFFECTS, 1969, London, England, 4.6%, E.
 9 JOURNAL OF LUMINESCENCE, Amsterdam, Netherlands, 4.6%, E, F, G, summaries in E.
 10 INTERNATIONAL JOURNAL OF CHEMICAL KINETICS, 1968, New York, U.S.A., 4.0%, E.
 11 FARADAY DISCUSSIONS, 1946, London, England, 3.6%, E.
 12 TOPICS IN CURRENT CHEMISTRY, 1949, Berlin, West Germany, 3.5%, E.
 13 RCA REVIEW, 1936, Princeton, N.J., 3.2%, E.
 14 CZECHOSLOVAK JOURNAL OF PHYSICS, 1952, Prague, Czechoslovakia, 3.2%, E, F, G, summaries in E.
 15 JOURNAL OF PHYSICAL AND CHEMICAL REFERENCE DATA, 1972, New York, U.S.A., 2.9%, E.
 16 JOURNAL OF NUCLEAR MATERIALS, 1959, Amsterdam, Netherlands, 2.9%, E, F, G.
 17 ZEITSCHRIFT FÜR PHYSIK, SECTION B: QUANTA AND MATTER, 1971, West Germany, 2.8%, E, F, G, summaries in E.
 18 CHEMISTRY IN BRITAIN, 1965, London, England, 2.7%, E.
 19 MOLECULAR PHOTOCHEMISTRY, 1969, New York, U.S.A., 2.6%, E.
 20 FERROELECTRICS, 1970, London, England, 2.4%, E.
 21 ADVANCES IN PHOTOCHEMISTRY,* 1963, New York, U.S.A., 2.3%, E.
 22 ADVANCES IN ATOMIC AND MOLECULAR PHYSICS, 1965, New York, U.S.A., 2.1%, E.
 23 PHYSICA (B & C), 1934, Amsterdam, Netherlands, 2.9%, E.
 24 JOURNAL OF PHOTOCHEMISTRY, 1972, Lausanne, Switzerland, 2.0%, E, F, G.
 25 COMPUTER PHYSICS COMMUNICATIONS, 1970, Amsterdam, Netherlands, 1.9%, E.
 26 NUCLEAR SCIENCE AND ENGINEERING, 1956, La Grange Pk., Ill., 1.8%, E.
 27 ADVANCES IN QUANTUM CHEMISTRY,* 1964, New York, U.S.A., 1.7%, E.
 28 JOURNAL OF ELECTRONIC MATERIALS, 1979, New York, U.S.A., 1.3%, E.
 29 AMERICAN NUCLEAR SOCIETY TRANSACTIONS, 1958, La Grange, Ill., 1.1%, E.
 30 NUCLEAR TECHNOLOGY, 1965, La Grange Pk., Ill., 0.6%, E.

Environmental Sciences and Chemical Analysis

- 9:42: 1 ENVIRONMENTAL SCIENCE AND TECHNOLOGY, 1967, Washington, D.C., 9.4%, E.
 2 BRITISH JOURNAL OF INDUSTRIAL MEDICINE, 1944, London, England, 8.3%, E.
 3 APPLIED SPECTROSCOPY, 1946, Baltimore, Md., 8.0%, E.

R.F.

- 9:42: 4 ANALYTICAL LETTERS, 1968, New York, U.S.A., 7.0%, E.
 5 BULLETIN OF ENVIRONMENTAL CONTAMINATION AND TOXICOLOGY, 1966, New York, U.S.A., 6.8%, E.
 6 FOOD AND COSMETICS TOXICOLOGY, 1963, Elmsford, N.Y. and Oxford, England, 6.3%, E, F, G.
 7 WATER RESEARCH, 1967, Elmsford, N.Y. and Oxford, England, 6.1%, E.
 8 ENVIRONMENTAL RESEARCH, 1967, New York, U.S.A., 4.5%, E.
 9 MIKROCHIMICA ACTA, 1937, Berlin, West Germany, and New York, U.S.A., 4.4%, summaries in several languages.
 10 WATER POLLUTION CONTROL FEDERATION JOURNAL, 1928, Washington, D.C., 4.1%, summaries in E, F, G, Sp, Port.
 11 JOURNAL OF OCCUPATIONAL MEDICINE, 1959, Chicago, Ill., 3.9%, E.
 12 BUNSKI KAGUKU, 1952, Tokyo, Japan, 3.5%, J, summaries in E.
 13 CHROMATOGRAPHIA, 1968, Weisbaden, West Germany, 3.4%, E, F, G.
 14 ATMOSPHERIC ENVIRONMENTS, 1967, Elmsford, N.Y. and Oxford, England, 3.1%, E, F, G.
 15 AMERICAN INDUSTRIAL HYGIENE ASSOCIATION, JOURNAL, 1940, Baltimore, Md., 3.0%, E.
 16 JOURNAL OF ENVIRONMENTAL QUALITY, 1972, Madison, Wisc., 2.5%, E.
 17 ENVIRONMENTAL HEALTH PERSPECTIVES, 1972, Triangle Pk., N.C., 2.5%, E.
 18 AIR POLLUTION CONTROL ASSOCIATION, JOURNAL, 1951, Pittsburgh, Pa., 2.4%, E.
 19 AMERICAN WATER WORKS ASSOCIATION, JOURNAL, 1914, Denver, Col., 2.1%, E.
 20 JOURNAL OF RADIOANALYTICAL CHEMISTRY, 1968, Lausanne, Switzerland, 2.1%, E, F, G.
 21 CHEMIA ANALYTICZNA, 1956, Warsaw, Poland, 2.0%, Polish, summaries in R, E, G, F.
 22 RADIOCHEMICAL AND RADIOANALYTICAL LETTERS, 1969, Lausanne, Switzerland, 1.9%, E, F, G.
 23 SPECTROCHIMICA ACTA, PART B: ATOMIC SPECTROSCOPY, 1939, Elmsford, N.Y. and Oxford, England, 1.7%, E, F, G.
 24 RADIOCHIMICA ACTA, 1962, Weisbaden, West Germany, 1.0%, E, F, G.

Clinical Pharmacology, Geriatrics

- 2:43: 1 EUROPEAN JOURNAL OF CLINICAL PHARMACOLOGY, 1968, New York, U.S.A., 7.1%, E.
 2 JOURNAL OF GERONTOLOGY, 1946, Washington, D.C., 5.5%, E.
 3 CURRENT THERAPEUTIC RESEARCH; CLINICAL AND EXPERIMENTAL, 1974, Tenafly, N.Y., 5.3%, E.
 4 JOHNS HOPKINS MEDICAL JOURNAL, 1889, Baltimore, Md., 4.8%, E.
 5 DRUG METABOLISM AND DISPOSITION, 1973, Baltimore, Md., 4.7%, E.
 6 PHARMACOLOGY, 1959, Basel, Switzerland, 4.5%, E.
 7 ANGIOLOGY, 1950, Baltimore, Md., 4.4%, E.
 8 JAPANESE JOURNAL OF PHARMACOLOGY, 1951, Kyoto, Japan, 4.3%, E.
 9 JOURNAL OF CLINICAL PHARMACOLOGY, 1961, Stamford, Conn., U.S.A., 3.9%, E.
 10 PRACTITIONER, 1868, Edinburgh, Scotland, 3.8%, E.
 11 NEW ZEALAND MEDICAL JOURNAL, 1885, Dunedin, New Zealand, 3.6%, E.
 12 ROYAL COLLEGE OF SURGEONS OF ENGLAND, ANNALS, 1947, London, England, 3.5%, E.
 13 SCOTTISH MEDICAL JOURNAL, 1956, Edinburgh, Scotland, 3.5%, E.
 14 GERIATRICS: A MEDICAL WORLD NEWS PUBLICATION, New York, U.S.A., 3.4%, E.
 15 BRITISH JOURNAL OF CLINICAL PHARMACOLOGY, 1974, London, England, 3.3%, E.

LIST OF JOURNALS IN EACH FRONT - Continued

R.F.

Clinical Pharmacology, Geriatrics - Concluded

- 2:43:16 DRUGS, 1971, Sydney, Australia, 2.9%, E.
 17 XENOBIOTICA, 1971, London, England, 2.9%, E.
 18 AGENTS AND ACTIONS, 1969, Basel, Switzerland, 2.8%, E.
 19 CANADIAN JOURNAL OF SURGERY/JOURNAL CANADIEN DE CHIRURGIE, 1957, Ottawa, Ontario, 2.7%, E, F.
 20 MINNESOTA MEDICINE, 1918, St. Paul, Minn., 2.7%, E.
 21 AUSTRALIAN AND NEW ZEALAND JOURNAL OF MEDICINE, 1952, Sydney, Australia, 2.7%, E.
 22 AMERICAN GERIATRICS SOCIETY, JOURNAL, 1953, New York, U.S.A., 2.6%, E.
 23 CHEMOTHERAPY, 1960, Basel, Switzerland, 2.6%, E.
 24 JOURNAL OF CARDIOVASCULAR SURGERY, 1960, Turin, Italy, 2.2%, E.
 25 INTERNATIONAL JOURNAL OF CLINICAL PHARMACOLOGY, 1967, Deisenhofen, West Germany, 2.1%, E, G.
 26 PHARMACOLOGICAL RESEARCH COMMUNICATIONS, 1969, New York, U.S.A., 2.0%.
 27 JOURNAL DE PHARMACOLOGIE, 1970, Paris, France, 1.9%, summaries in E.
 28 JOURNAL OF INTERNATIONAL MEDICAL RESEARCH, 1972, Northampton, England, 1.2%, E.
 29 THERAPIE, 1866, Paris, France, 1.2%, E, F.
 30 JOURNAL OF PHARMACOKINETICS AND BIOPHARMACEUTICS, 1973, New York, U.S.A., 1.0%, E.
 31 GERONTOLOGIST, 1961, Washington, D.C., 0.6%, E.

Anaesthesiology

- 2:44: 1 ANAESTHESIOLOGY, 1940, Philadelphia, Pa., 47.7%, E.
 2 BRITISH JOURNAL OF ANAESTHESIA, 1923, London, England, 30.3%, E, summaries in G, Sp.
 3 CURRENT RESEARCHES IN ANAESTHESIA AND ANALGESIA,* 1972, Cleveland, Ohio, 19.0%, E.
 4 ANAESTHESIA, 1946, Oxford, England, 8.3%, E.
 5 CANADIAN ANAESTHETISTS SOCIETY, JOURNAL, 1954, Toronto, Ontario, 7.9%, E.
 6 ACTA ANAESTHESIOLOGICA SCANDINAVICA, 1957, Copenhagen, Denmark, 5.8%, E.

Secondary Psychiatry and Psychology

- 10:45: 1 PSYCHOPHYSIOLOGY, 1964, Madison, Wisc., 8.1%, E.
 2 JOURNAL OF PSYCHIATRIC RESEARCH, 1961, Elmsford, N.Y. and Oxford, England, 7.1%, E.
 3 NEUROPSYCHOLOGIA, 1963, Elmsford, N.Y. and Oxford, England, 7.1%, E, F, G.
 4 PSYCHOLOGY TODAY, 1967, New York, U.S.A., 5.7%, E.
 5 PSYCHIATRY, 1938, Washington, D.C., 5.7%, E.
 6 ANNUAL REVIEW OF PSYCHOLOGY, 1950, Palo Alto, Cal., 5.3%, E.
 7 PSYCHOLOGICAL MEDICINE, 1970, Cambridge, England, 4.9%, E.
 8 BIOLOGICAL PSYCHIATRY, 1969, New York, U.S.A., 4.8%, E.
 9 JOURNAL OF GENERAL PSYCHOLOGY, 1927, Provincetown, Mass., 4.8%, E.
 10 BEHAVIORAL SCIENCE, 1956, Louisville, Ky., 4.7%, E.
 11 CANADIAN JOURNAL OF PSYCHOLOGY/REVUE CANADIENNE DE PSYCHOLOGIE, 1947, Toronto, Canada, 4.6%, E, F.
 12 COMPREHENSIVE PSYCHIATRY, 1960, New York, U.S.A., 4.4%.
 13 PSYCHOLOGICAL RECORD, 1937, Gambier, Ohio, 3.6%, E.
 14 ACTA PSYCHOLOGICA, 1950, Amsterdam, Netherlands, 3.3%, E.

R.F.

- 10:45:15 PSYCHONOMIC SOCIETY, BULLETIN, 1964, Austin, Texas, 3.0%, E.
 16 BRITISH JOURNAL OF MEDICAL PSYCHOLOGY, 1920, Leicester, England, 3.0%, E.
 17 INTERNATIONAL JOURNAL OF PSYCHO-ANALYSIS, 1920, London, England, 2.8%, E.
 18 QUARTERLY JOURNAL OF EXPERIMENT PSYCHOLOGY, 1948, London, England, 2.5%, E.
 19 CANADIAN PSYCHIATRIC ASSOCIATION JOURNAL, 1956, Ottawa, Canada, 2.4%, E.
 20 PSYCHOSOMATICS, 1960, Greenwich, Conn., 2.4%, E.
 21 PHYSIOLOGICAL PSYCHOLOGY, 1973, Austin, Texas, 2.3%, E.
 22 AMERICAN PSYCHOANALYTIC ASSOCIATION, JOURNAL, 1953, New York, U.S.A., 2.0%, E.
 23 AMERICAN JOURNAL OF PSYCHOTHERAPY, 1946, New York, U.S.A., 1.9%, E.
 24 PSYCHOANALYTIC QUARTERLY, 1932, New York, U.S.A., 1.8%, E.
 25 ANIMAL LEARNING AND BEHAVIOUR, 1973, Austin, Texas, 1.0%, E.
 26 LEARNING AND MOTIVATION, 1970, New York, U.S.A., 0.8%, E.

Clinical Medicine, Reproductive Biology

- 2:46: 1 FERTILITY AND STERILITY, 1949, Birmingham, Ala., 5.2%, E.
 2 BRITISH JOURNAL OF UROLOGY, 1929, London, England, 5.1%, E.
 3 CLINICAL ENDOCRINOLOGY, 1972, Oxford, England, 4.3%, E.
 4 BIOMEDICINE, 1956, Paris, France, 4.2%, E, F.
 5 CLINICA HAEMATOLOGICA, 1974, Barcelona, Spain, 3.8%, E.
 6 PATHOLOGIE BIOLOGIE, 1953, Paris, France, 3.5%, F.
 7 HISTOCHEMISTRY, 1958, New York, U.S.A., 3.4%, E, F, G, summaries in E.
 8 ACTA OBSTETRICA ET GYNECOLOGICA SCANDINAVICA, 1922, Stockholm, Sweden, 3.3%, E.
 9 VIRCHOWS ARCHIV B: CELL PATHOLOGY, 1968, New York, U.S.A. and Berlin, West Germany, 3.1%, E, G.
 10 ACTA PATHOLOGICA ET MICROBIOLOGICA SCANDINAVICA, SECTION A: PATHOLOGY, 1926, Copenhagen, Denmark, 2.9%, E.
 11 CURRENT TOPICS IN MICROBIOLOGY AND IMMUNOLOGY, 1973, Berlin, West Germany, 2.6%, E.
 12 ANNALES D'ENDOCRINOLOGIE, 1973, Paris, France, 2.5%, E, F.
 13 NOUVELLE REVUE FRANCAISE D'HEMATOLOGIE, 1946, New York, U.S.A., 2.5%, summaries in E.
 14 TISSUE AND CELL, 1969, Edinburgh, Scotland, 2.5%, E, F, G.
 15 ACTA CYTOLOGICA, 1957, Baltimore, Md., 2.3%, E.
 16 BLUT, ZEITSCHRIFT FÜR DIE GESAMTE BLUTFORSCHUNG, 1950, Berlin, West Germany and New York, U.S.A., 2.3%, E, G.
 17 JOURNAL OF MICROSCOPY, 1878, Oxford, England, 2.2%, E.
 18 INVESTIGATIVE UROLOGY, 1963, Baltimore, Md., 2.2%, E.
 19 ZEITSCHRIFT FÜR IMMUNITÄTSFORSCHUNG, EXPERIMENTELLE UND KLINISCHE IMMUNOLOGIE, 1908, Stuttgart, West Germany, 2.1%, G.
 20 C.R.C. CRITICAL REVIEWS IN BIOCHEMISTRY, 1971, Boca Raton, Fla., 2.1%, E.
 21 CONTRACEPTION, 1970, Los Altos, Cal., 2.0%, E.
 22 PROGRESS IN MEDICAL VIROLOGY, 1958, Basel, Switzerland, 2.0%, E.
 23 CLINICAL OBSTETRICS AND GYNECOLOGY: A QUARTERLY PERIODICAL, 1958, Hagerstown, Mo., 2.0%, E.
 24 METHODS IN CELL BIOLOGY,* 1973, New York, U.S.A., 2.0%, E.

LIST OF JOURNALS IN EACH FRONT - Continued

R.F.

**Clinical Medicine, Reproductive Biology -
Concluded**

- 2:46:25 WILHELM ROUX'S ARCHIVES OF DEVELOPMENTAL BIOLOGY, Berlin, West Germany, New York, U.S.A., 1.9%, F.
- 26 HISTOCHEMICAL JOURNAL, 1968, London, England, 1.9%, E.
- 27 INTERVIROLOGY, 1973, Basel, Switzerland, 1.8%, E.
- 28 BIOPHYSICAL CHEMISTRY, 1974, Amsterdam, Netherlands, 1.8%, E.
- 29 BRITISH JOURNAL OF OBSTETRICS AND GYNAECOLOGY, 1902, London, England, 1.7%, E.
- 30 ARCHIVES D'ANATOMIE MICROSCOPIQUE ET DE MORPHOLOGIE EXPERIMENTALE, 1897, Paris, France, 1.7%, F.
- 31 CELL DIFFERENTIATION, 1972, Limerick, Ireland, 1.7%, E.
- 32 ACTA HISTOCHEMICA ET CYTOCHEMICA, 1960, Kyoto, Japan, 1.6%, E, F, G, summaries in E.
- 33 IMMUNOLOGICAL COMMUNICATIONS, 1972, New York, U.S.A., 1.4%, E.
- 34 ARCHIVES OF GYNECOLOGY,* 1870, New York, U.S.A., 1.4%, E.
- 35 ADVANCES IN VIRUS RESEARCH, 1953, New York, U.S.A., 1.3%, E.
- 36 DIFFERENTIATION: RESEARCH IN BIOLOGICAL DIVERSITY, 1973, New York, U.S.A., 1.3%, E.
- 37 IMMUNOLOGIA POLSKA (FORMERLY ANNALS OF IMMUNOLOGY), 1969, Warsaw, Poland, 1.2%, Polish, E.
- 38 CURRENT TOPICS IN DEVELOPMENTAL BIOLOGY, 1966, New York, U.S.A., 1.2%, E.
- 39 JOURNAL OF REPRODUCTIVE MEDICINE, 1968, St. Louis, Mo., 1.2%, E.
- 40 EXPERIMENTAL HEMATOLOGY, 1973, El Paso, Texas, 1.2%, E.
- 41 SCANDINAVIAN JOURNAL OF UROLOGY AND NEPHROLOGY, 1967, Stockholm, Sweden, 1.2%, E.
- 42 MOLECULAR BIOLOGY REPORTS, 1973, The Hague, Netherlands, 1.1%, E.
- 43 PROGRESS IN HAEMATOLOGY, 1956, New York, U.S.A., 1.1%, E.
- 44 BIKEN JOURNAL, 1958, Osaka, Japan, 1.0%, European languages.
- 45 ACTA VIROLOGICA, 1957, Prague, Czechoslovakia, 0.9%, E.
- 46 GEBURTSILFE UND FRAUENHEILKUNDE, 1940, Stuttgart, West Germany, 0.9%, summaries in E, G.
- 47 ARCHIVUM HISTOLOGICUM JAPONICUM, 1950, Nügata, Japan, 0.8%, E.
- 48 SOMATIC CELL GENETICS, 1979, New York, U.S.A., 0.8%, E.
- 49 ARCHIVES OF VIROLOGY, 1939, New York, U.S.A., 0.7%, E.

Applied Mathematics and Computer Science

- 14:47: 1 COMPUT J
2 MATH COMPUT
3 IEEE T MICROW THEORY
4 IEEE T AUTOMAT CONTR
5 AM MATH MDN
6 P I ELECT ENG
7 NUMER MATH
8 Q J MATH
9 ADV MATH
10 COMMUN ACM
11 B SOC MATH FR
12 J ASSOC COMPUT MACH
13 INDIANA U MATH J
14 ARCH MATH
15 IEEE T INFORM THEORY
16 SIAM REV
17 COMMENT MATH HELV
18 MICH MATH H
19 J DIFFER EQUATIONS

R.F.

- 14:47:20 MATH SCAND
21 SIAM J NUMER ANAL
22 SIAM J CONTROL OPTIM
23 NAGOYA MATH J
24 J MATH SOC JPN
25 IEEE T ANTENN PROPAG
26 INFORM CONTR
27 MEM AM MATH SOC
28 INT J CONTROL
29 IEEE T COMPUT
30 COMPOS MATH
31 AUTOMATICA
32 IEEE T COMMUN
33 J MATH PURE APPL
34 J I MATH APPL
35 IEEE T POWER AP SYS
36 SIAM J MATH ANAL
37 J OPTIMIZ THEORY APP

Secondary Geophysics, Atmospheric Sciences

- 9:48: 1 JOURNAL OF THE ATMOSPHERIC SCIENCES, 1944, Boston, Mass., 31.7%, E.
2 TELLUS, A JOURNAL OF GEOPHYSICS, 1949, Copenhagen, Denmark, 17.4%, E, F, G, summaries in E, R.
3 ROYAL METEOROLOGICAL SOCIETY, QUARTERLY JOURNAL, 1871, Bracknell, England, 15.0%, E.
4 JOURNAL OF APPLIED METEOROLOGY, 1962, Boston, Mass., 13.4%, E.
5 MONTHLY WEATHER REVIEW, 1872, Boston, Mass., 10.8%, E.
6 PURE AND APPLIED GEOPHYSICS, 1939, Basel, Switzerland, 6.8%, E, F, G, I.
7 JOURNAL OF PHYSICAL OCEANOGRAPHY, 1971, Boston, Mass., 5.0%, E.

Secondary Plant Biology

- 10:49: 1 ZEITSCHRIFT FÜR NATURFORSCHUNG, SECTION C: BIOSCIENCES, 1946, Tuebingen, West Germany, 11.1%, E, G.
2 PLANT SCIENCE LETTERS, 1973, Limerick, Ireland, 8.3%, E.
3 DEUTSCHE BOTANISCHE GESELLSCHAFT, BERICHTE, 1882, Stuttgart, West Germany, 6.5%, E.
4 JOURNAL OF GENETICS, 1910, Hyderabad, India, 6.3%, E.
5 ADVANCES IN GENETICS, 1947, New York, U.S.A., 5.5%, E.
6 BIOLOGISCHES ZENTRALBLATT, 1881, Leipzig, East Germany, 5.4%, G, E.
7 CYTOLOGIA, 1929, Tokyo, Japan, 5.3%, European languages.
8 PHYSIOLOGIE VEGATALE, 1963, Paris, France, 4.3%, summaries in E, F.
9 JAPANESE JOURNAL OF GENETICS, 1921, Tokyo, Japan, 4.2%, E, J.
10 TORREY BOTANY CLUB, BULLETIN, 1870, Brockport, N.Y., 4.0%, E.
11 BIOCHEMIE UND PHYSIOLOGIE DER PFLANZEN, 1970, Jena, East Germany, 3.9%, E, F, G, summaries in E, G.
12 ACTA BOTANICA NEERLANDICA, 1952, Leiden, Netherlands, 3.8%, mainly E.
13 CARYOLOGIA, 1948, Florence, Italy, 3.8%, E, F, G, I, Sp, summaries in E.
14 EUPHYTICA, 1952, Wageningen, Netherlands, 3.7%, E.
15 FLORA, 1937, Quito, Equador, 3.6%, E, Sp.
16 GENETICA, 1919, The Hague, Netherlands, 3.5%, E, F, G, I.
17 PHOTOSYNTHETICA, 1967, Prague, Czechoslovakia, 3.0%, E, F, G, summaries in E.
18 BOTANICAL MAGAZINE, 1887, Tokyo, Japan, 2.9%, E, J.
19 PHYTOMORPHOLOGY, 1951, Delhi, India, 2.6%, E, F, G.

LIST OF JOURNALS IN EACH FRONT - Continued

R.F.

Secondary Plant Biology - Concluded

- 10:49:20 TAXON, 1951, Utrecht, Netherlands, 2.5%, E, F, G, I, Sp.
 21 THEORETICAL AND APPLIED GENETICS, 1929, Berlin, West Germany, 2.4%, E.
 22 ZEITSCHRIFT FUER PFLANZENZUECHTUNG/JOURNAL OF PLANT BREEDING, Berlin, West Germany, 2.1%, E, F, G, summaries in E, G.
 23 MISSOURI BOTANICAL GARDEN, ANNALS, 1914, St. Louis, Mo., 1.5%, E, Latin descriptions.

Applied Statistics, Population Biology

- 10:50: 1 BIOMETRICS, 1945, Raleigh, N.C., 6.2%, E, F, G.
 2 CALCIFIED TISSUE RESEARCH, 1967, New York, U.S.A., 5.1%, E.
 3 TOHOKU JOURNAL OF EXPERIMENTAL MEDICINE, 1920, Sendai, Japan, 4.6%, E, F, G.
 4 BIOLOGY OF THE NEONATE, FETAL AND NEONATAL RESEARCH, 1951, Basel, Switzerland, 4.6%, E.
 5 AMERICAN STATISTICAL ASSOCIATION, JOURNAL, 1888, Washington, D.C., 4.3%, E.
 6 POULTRY SCIENCE, 1908, Stratton, Texas, 4.2%, E.
 7 PUBLIC HEALTH REPORTS, 1878, Rockville, Md., 3.9%, E.
 8 WIENER KLINISCHE WOCHENSCHRIFT, 1887, Vienna, Austria, 3.7%, G.
 9 STROKE: A JOURNAL OF CEREBRAL CIRCULATION, 1970, Dallas, Texas, 3.5%, E.
 10 PSYCHOMETRIKA, 1936, Chicago, Ill., 3.4%, E.
 11 BRITISH JOURNAL OF PREVENTIVE AND SOCIAL MEDICINE, 1947, London, England, 3.3%, E.
 12 BIOMETRIKA, 1901, London, England, 3.2%, E.
 13 ADVANCES IN LIPID RESEARCH, 1963, New York, U.S.A., 3.1%, E.
 14 ARCHIV FUER PSYCHIATRIE UND NERVENKRANKHEITEN, 1868, Berlin, West Germany and New York, U.S.A., 2.7%, E, G.
 15 ENZYME, 1961, Basel, Switzerland, 2.6%, E.
 16 NUTRITION SOCIETY, PROCEEDINGS, 1941, London, England, 2.5%, E.
 17 JOURNAL OF COUNSELLING PSYCHOLOGY, 1954, Washington, D.C., 2.5%, E.
 18 EUROPEAN NEUROLOGY, 1968, Basel, Switzerland, 2.2%, E.
 19 DEVELOPMENTAL MEDICINE AND CHILD NEUROLOGY, 1958, London, England, 2.1%, E, summaries in F, G, Sp.
 20 ACTA ORTHOPAEDICA SCANDINAVICA, 1930, Copenhagen, Denmark, 1.9%, E.
 21 LANGENBECK'S ARCHIV FUER CHIRURGIE, 1860, Berlin, West Germany, 1.8%, E.
 22 MONATSSCHRIFT FUER KINDERHEILKUNDE, 1903, Berlin, West Germany and New York, U.S.A., 1.6%, summaries in E, G.
 23 TECHNOMETRICS, 1959, Washington, D.C., 1.5%, E.
 24 JOURNAL OF MEDICAL EDUCATION, 1926, Washington, D.C., 1.4%, E.
 25 CHIRURG, 1928, Berlin, West Germany and New York, U.S.A., 1.4%, E.
 26 ADVANCES IN AGRONOMY, 1949, New York, U.S.A., 1.4%, E.
 27 NERVENARZT, 1928, Berlin, West Germany and New York, U.S.A., 1.3%, E.
 28 ROYAL STATISTICAL SOCIETY, JOURNAL, SERIES B: METHODOLOGICAL, 1934, London, England, 1.3%, E.
 29 NUTRITION AND METABOLISM, 1959, Basel, Switzerland, 1.2%, E.
 30 JOURNAL OF HEALTH AND SOCIAL BEHAVIOUR, 1960, Washington, D.C., 1.2%, E.
 31 INTERNIST, 1960, New York, U.S.A., 1.1%, E.
 32 MEDICAL CARE, 1967, Washington, D.C., 1.1%, E.
 33 ACTA NEUROCHIRURGICA, 1950, New York, U.S.A., 1.0%, E.

R.F.

- 10:50:34 CANADIAN JOURNAL OF ANIMAL SCIENCE, 1921, Ottawa, Canada, 0.9%, E, F.
 35 DEMOGRAPHY, 1964, Washington, D.C., 0.9%, E.
 36 NUTRITION REPORTS INTERNATIONAL, 1970, Los Altos, Cal., 0.9%, E.
 37 JOURNAL OF BIOMECHANICS, 1968, Oxford, England, 0.8%, E.
 38 MILBANK MEMORIAL FUND QUARTERLY: HEALTH AND SOCIETY, 1923, New York, U.S.A., 0.8%, E.
 39 PERSONNEL AND GUIDANCE JOURNAL, 1922, Washington, D.C., 0.8%, E.
 40 ANIMAL PRODUCTION, 1959, Edinburgh, Scotland, 0.7%, E.
 41 CANADIAN JOURNAL OF SOIL SCIENCES, 1921, Ottawa, Canada, 0.7%, E, F.
 42 NEUROPAEDIATRIE, 1969, Stuttgart, West Germany, 0.7%.
 43 CLAYS AND CLAY MINERALS, 1870, Elmsford, N.Y. and Oxford, England, 0.6%, E.
 44 POPULATION STUDIES, 1947, London, England, 0.6%, E.
 45 NEW ZEALAND JOURNAL OF AGRICULTURAL RESEARCH, 1958, Auckland, New Zealand, 0.6%, E.
 46 BRITISH GRASSLAND SOCIETY, JOURNAL, 1946, Maidenhead, England, 0.5%, E.
 47 HELVETICA CHIRURGICA ACTA, 1945, Basel, Switzerland, 0.5%, F, G, summaries in E.
 48 ZEITSCHRIFT FUER ORTHOPAEDIE UND IHRE GRENZGEBIETE, 1891, Stuttgart, West Germany, 0.5%, E, G.
 49 SCHWIEZER ARCHIV FUER NEUROLOGIE, NEUROCHIRURGIE UND PSYCHIATRIE, 1917, Zurich, Switzerland, 0.4%, E, F, G, I.
 50 BRITISH POULTRY SCIENCE, 1960, Edinburgh, Scotland, 0.4%, E.
 51 FORTSCHRITTE DER NEUROLOGIE, PSYCHIATRIE UND IHRER GRENZGEBIETE, 1931, Stuttgart, West Germany, 0.4%, G.
 52 ARCHIV FUER ORTHOPAEDISCHE UND UNFALL CHIRURGIE, 1903, Berlin, West Germany, New York, U.S.A., 0.4%, G.
 53 AUSTRALIAN JOURNAL OF SOIL RESEARCH, 1963, Melbourne, Australia, 0.3%, E.
 54 GEODERMA, AN INTERNATIONAL JOURNAL OF SOIL SCIENCE, 1967, Amsterdam, Netherlands, 0.3%, E, F, G.
 55 ANNALS OF STATISTICS, 1973, Hayward, Cal., 0.3%, E.

Secondary Chemical Engineering

- 7:51: 1 NIPPON KAGAKU KEISHI/CHEMICAL SOCIETY OF JAPAN, CHEMISTRY AND INDUSTRIAL CHEMISTRY, JOURNAL, 1972, Tokyo, Japan, 8.9%, J, summaries in E.
 2 ACTA CHEMICA SCANDINAVICA, SERIES B: ORGANIC CHEMISTRY AND BIOCHEMISTRY, 1947, Copenhagen, Denmark, 7.9%, E.
 3 JOURNAL OF APPLIED CHEMISTRY OF THE U.S.S.R., 1950, (English translation, New York, U.S.A.), 6.9%, E.
 4 CHEMICA SCRIPTA, 1971, Stockholm, Sweden, 6.4%, E.
 5 CHIMICA E L'INDUSTRIA, 1919, Milan, Italy, 6.3%, E.
 6 POLYMER JOURNAL, 1970, Tokyo, Japan, 5.7%, E.
 7 JOURNAL OF MACROMOLECULAR SCIENCE, PART A, CHEMISTRY, 1967, New York, U.S.A., 5.6%, E.
 8 CHEMICKÉ LISTY/JOURNAL OF CHEMISTRY, 1907, Prague, Czechoslovakia, 5.4%, Czech, Slovak, contents page and summaries in E.
 9 INDUSTRIAL AND ENGINEERING CHEMISTRY PROCESS DESIGN AND DEVELOPMENT, 1962, Washington, D.C., 5.1%, E.
 10 REVUE ROUMAINE DE CHIMIE, 1956, Bucharest, Romania, 4.9%, E, F, G, R, Sp.

LIST OF JOURNALS IN EACH FRONT - Continued

R.F.

Secondary Chemical Engineering - Concluded

- 7:51:11 POLYMER ENGINEERING AND SCIENCE, 1961, Greenwich, Conn., U.S.A., 4.7%, E.
- 12 ANNALES DE CHIMIE,* 1914, Paris, France, 4.6%, E, F.
- 13 JOURNAL OF MACROMOLECULAR SCIENCE, PART B, PHYSICS, 1967, New York, U.S.A., 4.5%, E.
- 14 JOURNAL OF FLUORINE CHEMISTRY, 1970, Lausanne, Switzerland, 4.1%, E.
- 15 ADVANCES IN ORGANIC CHEMISTRY,* 1972, New York, U.S.A., 4.1%, E.
- 16 JOURNAL OF APPLIED CHEMISTRY AND BIOTECHNOLOGY, 1951, Oxford, England, 3.9%, E.
- 17 ANGELWANDTE MAKROMOLEKULARE CHEMIE, 1967, Basel, Switzerland, 3.7%, G, E, F.
- 18 RHEOLOGICA ACTA, 1958, Darmstadt, West Germany, 2.6%, E, G.
- 19 COLLOID AND POLYMER SCIENCE, 1906, Darmstadt, West Germany, 2.5%, E, G.
- 20 MICROCHEMICAL JOURNAL, 1957, New York, U.S.A., 2.5%, E.
- 21 SOCIETY OF RHEOLOGY, TRANSACTIONS, 1957, New York, U.S.A., 2.2%, E.
- 22 CHEMICKÉ ZVESTI/SLOVENSKÁ CHEMICKÁ, 1947, Bratislava, Czechoslovakia, 1.9%, E.
- 23 JOURNAL OF MACROMOLECULAR SCIENCE, PART C, REVIEWS IN MACROMOLECULAR CHEMISTRY, 1967, New York, U.S.A., 1.9%, E.
- 24 ORGANIC PREPARATIONS AND PROCEDURES INTERNATIONAL, THE NEW JOURNAL FOR ORGANIC SYNTHESIS, 1971, Highlands, Mass., 1.3%, E.
- 25 ADVANCES IN POLYMER SCIENCE, 1958, Heidelberg, Vienna, 1.1%, G, E, F.

Secondary Law Group 2

- 14:52: 1 FORDHAM LAW REV
- 2 INDIANA LAW J
- 3 NOTRE DAME L
- 4 RUTGERS LAWYER
- 5 U CINCI LAW REV
- 6 BOSTON U LAW REV
- 7 OHIO STATE LAW J
- 8 WASH LAW REV
- 9 U ILLINOIS LAW FORUM
- 10 U PITT LAW REV
- 11 BUFFALO LAW REV
- 12 SYRACUSE LAW REV
- 13 AM CRIM LAW REV
- 14 KY LAW J
- 15 J LEGAL STUD
- 16 OKLA LAW REV

Secondary Applied Physics

- 7:53: 1 JOURNAL OF QUANTITATIVE SPECTROSCOPY AND RADIATIVE TRANSFER, 1961, Elmsford, N.Y. and Oxford, England, 13.3%, E, F, G, R.
- 2 AUSTRALIAN JOURNAL OF PHYSICS, 1948, Melbourne, Australia, 9.4%, E.
- 3 AMERICAN JOURNAL OF PHYSICS, 1933, New York, U.S.A., 8.4%, E.
- 4 PHYSICS TODAY, 1948, New York, U.S.A., 5.5%, E.
- 5 REVUE DE PHYSIQUE APPLIQUEE (SUPPLEMENT TO THE JOURNAL DE PHYSIQUE), 1966, Paris, France, 4.8%, E, F.
- 6 JOURNAL OF COMPUTATIONAL PHYSICS, 1966, New York, U.S.A., 4.7%, E.
- 7 CRYOGENICS, 1960, Guildford, England, 4.7%, E.
- 8 PROGRESS IN SOLID STATE CHEMISTRY, 1964, Elmsford, N.Y. and Oxford, England, 4.5%, E.
- 9 ANNALES DE PHYSIQUE, 1914, Paris, France, 4.3%, E, F.
- 10 INDIAN JOURNAL OF PURE AND APPLIED PHYSICS, 1963, New Delhi, India, 4.3%, E.

R.F.

- 7:53:11 ACTA PHYSICA POLONICA (SERIES A: GENERAL PHYSICS, SOLID STATE PHYSICS, APPLIED PHYSICS), 1932, Warsaw, Poland, 4.1%, various.
- 12 JOURNAL OF STATISTICAL PHYSICS, 1969, New York, U.S.A., 4.1%, E.
- 13 METHODS IN COMPUTATIONAL PHYSICS, 1963, New York, U.S.A., 3.6%, E.
- 14 SPRINGER TRACTS IN MODERN PHYSICS, 1964, New York, U.S.A., 3.5%, E.
- 15 JOURNAL DE PHYSIQUE LETTERS, 1872, Paris, France, 3.3%, summaries in E, F.
- 16 PHYSICAL ACOUSTICS: PRINCIPLES AND METHODS,* 1964, New York, U.S.A., 3.2%, E.
- 17 CRC CRITICAL REVIEWS IN SOLID STATE AND MATERIALS SCIENCES, 1970, Cleveland, Ohio, 3.0%, E.
- 18 PHYSICA: EUROPHYSICS JOURNAL, 1934, Amsterdam, Netherlands, 2.2%, E, F, G.
- 19 CONTEMPORARY PHYSICS, 1959, London, England, 2.2%, E.
- 20 ACTA PHYSICA AUSTRIACA (E.P.S. EUROPHYSICS JOURNAL), 1947, Springer-Verlag (Berlin, New York), 1.9%.
- 21 INDIAN JOURNAL OF PHYSICS AND PROCEEDINGS OF THE INDIAN ASSOCIATION FOR THE CULTIVATION OF SCIENCE, 1926, Calcutta, India, 1.8%, E.
- 22 ASTRONOMICAL SOCIETY OF JAPAN, PUBLICATION, 1949, Tokyo, Japan, 1.5%, E.
- 23 ASTRONOMICHESKII ZHURNALS, 1924, Podsolenskii, U.S.S.R., 1.4%, R.
- 24 FORTSCHRITTE DER PHYSIK, 1953, Berlin, East Germany, 1.3%, E, G.
- 25 OBSERVATORY, 1877, Hailsham, England, 1.0%, E.
- 26 RIVISTA DEL NUOVO CIMENTO, 1969, Bologna, Italy, 1.0%, E.

Marine Biology

- 10:54: 1 JOURNAL OF PSYCOLOGY, 1965, Columbus, Ohio, 12.7%, E, F, G, Sp, summaries in E.
- 2 AMERICAN MICROSCOPICAL SOCIETY, TRANSACTIONS, 1880, Lawrence, Kansas, 8.8%, E.
- 3 JOURNAL OF EXPERIMENTAL MARINE BIOLOGY AND ECOLOGY, Amsterdam, Netherlands, 8.2%, E.
- 4 JAPANESE SOCIETY OF SCIENTIFIC FISHERIES, BULLETIN, 1932, Tokyo, Japan, 6.4%, E, summaries in European languages.
- 5 ZOOLOGISCHER ANZEIGER, 1878, Jena, East Germany, 6.0%, E, F, G, summaries in E, G.
- 6 INTERNATIONAL JOURNAL FOR PARASITOLOGY, 1971, Elmsford, N.Y. and Oxford, England, 5.4%, E.
- 7 JOURNAL OF FISH BIOLOGY, 1969, New York, U.S.A., 5.3%, E.
- 8 ZEITSCHRIFT FUER PARASITENKUNDE, 1928, New York, U.S.A., 4.9%, E, F, G, summaries in E.
- 9 FISH BULLETIN, 1935, Sacramento, Cal., 4.4%, E.
- 10 ARCHIVES DE ZOOLOGIE EXPERIMENTALE ET GENERALE, 1972, Paris, France, 4.2%, F.
- 11 JOURNAL DU CONSEIL, INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA, 1926, 3.9%, E, F.
- 12 SOCIETE ZOOLOGIQUE DE FRANCE, BULLETIN, 1976, Paris, France, 3.7%, E, F, G.
- 13 HELGOLANDER WISSENSCHAFTLICHE MEERESUNTERSUCHUNGEN (MARINE INVESTIGATIONS), 1937, Hamburg, West Germany, 3.6%, E, F, G.
- 14 PROGRESSIVE FISH CULTURALIST, 1938, Washington, D.C., 3.3%, E.
- 15 ANNALES DES SCIENCES NATURELLES, ZOOLOGIE ET BIOLOGIE ANIMALE, 1824, Paris, France, 2.3%, summaries in E, F.
- 16 HELMINTHOLOGICAL SOCIETY OF WASHINGTON, PROCEEDINGS, 1934, Lawrence, Kansas, 2.9%, E.
- 17 PACIFIC SCIENCE, 1947, Honolulu, Hawaii, 2.7%, E.
- 18 JOURNAL OF HELMINTHOLOGY, 1923, London, England, 2.4%, E.

LIST OF JOURNALS IN EACH FRONT - Continued

R.F.

Marine Biology - Concluded

- 10:54:19 BULLETIN OF MARINE SCIENCES, 1951, Miami, Fla., 3.3%, E, Sp.
 20 AUSTRALIAN JOURNAL OF MARINE AND FRESHWATER RESEARCH, 1950, Melbourne, Australia, 2.2%, E.
 21 ADVANCES IN PARASITOLOGY, 1963, New York, U.S.A., 2.0%, E.
 22 PROTISTOLOGICA, 1965, Paris, France, 1.6%, E, F.

Applied Economics

- 14:55: 1 MANAGEMENT SCIENCE, 1954, Providence, R.I., 11.2%, E.
 2 HARVARD BUSINESS REVIEW, 1922, Boston, Mass., 10.6%, E.
 3 OPERATIONS RESEARCH, 1952, Baltimore, Md., 10.1%.
 4 JOURNAL OF FINANCE, 1946, New York, U.S.A., 8.1%, E.
 5 JOURNAL OF LAW AND ECONOMICS, 1958, Chicago, Ill., 6.9%, E.
 6 BELL JOURNAL OF ECONOMICS AND MANAGEMENT SCIENCE, 1970, New York, U.S.A., 5.8%, E.
 7 JOURNAL OF BUSINESS, 1928, Chicago, Ill., 5.6%, E.
 8 SOUTHERN ECONOMIC JOURNAL, 1933, Chapel Hill, N.C., 5.2%, E.
 9 JOURNAL OF ECONOMIC LITERATURE, 1963, Nashville, Tenn., 5.0%, E.
 10 JOURNAL OF MARKETING RESEARCH, 1964, Chicago, Ill., 4.0%, E.
 11 NATIONAL TAX JOURNAL, 1948, Columbus, Ohio, 4.0%, E.
 12 OXFORD ECONOMIC PAPERS, 1938, London, England, 3.7%, E.
 13 CANADIAN JOURNAL OF ECONOMICS/REVUE CANADIENNE D'ECONOMIQUE, 1968, Toronto, Canada, 3.6%, E, F.
 14 JOURNAL OF MARKETING, 1936, Chicago, Ill., 3.4%, E.
 15 JOURNAL OF MONEY, CREDIT AND BANKING, 1969, Columbus, Ohio, 3.2%, E.
 16 MATHEMATICAL PROGRAMMING, 1978, Amsterdam, Netherlands, 2.8%, E.
 17 JOURNAL OF PUBLIC ECONOMICS, 1972, Amsterdam, Netherlands, 2.5%, E.
 18 BROOKINGS PAPERS ON ECONOMIC ACTIVITY, 1970, Washington, D.C., 2.4%, E.
 19 ACCOUNTING REVIEW, 1926, Sarasota, Fla., 1.9%, E.

Biomedical Engineering, Respiratory Diseases

- 2:56: 1 JOURNAL OF NUCLEAR MEDICINE, 1960, New York, U.S.A., 15.2%, E.
 2 AMERICAN SOCIETY FOR ARTIFICIAL INTERNAL ORGANS, TRANSACTIONS, 1955, Washington, D.C., 8.6%, E.
 3 ANNALS OF CLINICAL RESEARCH, 1969, Helsinki, Finland, 5.7%, E.
 4 INTERNATIONAL JOURNAL OF APPLIED RADIATION AND ISOTOPES, 1956, Elmsford, N.Y. and Oxford, England, 4.8%, E, F, G, R.
 5 ANNALS OF ALLERGY, 1943, Minneapolis, Minn., 4.7%, E.
 6 BRITISH JOURNAL OF DISEASES OF THE CHEST, 1907, London, England, 3.8%, E.
 7 JAPANESE CIRCULATION JOURNALS, 1947, Kyoto, Japan, 3.7%, J, E.
 8 HEALTH PHYSICS, 1958, Elmsford, N.Y. and Oxford, England, 3.6%, E.
 9 STRAHLENTHERAPIE, ARCHIVES OF CLINICAL AND EXPERIMENTAL RADIOLOGY, 1912, Munich, West Germany, 3.3%, G, summaries in E, F, G.
 10 ARCHIVES DES MALADIES DU COEUR ET DES

R.F.

- 2:56:10 VAISSEAU, 1908, Paris, France, 3.3%, F.
 11 SCANDINAVIAN JOURNAL OF RESPIRATORY DISEASES, 1924, Copenhagen, Denmark, 3.1%, E.
 12 ACTA ALLERGologica, 1948, Copenhagen, Denmark, 3.0%, E, F, G, summaries in E.
 13 DANISH MEDICAL BULLETIN, 1954, Copenhagen, Denmark, 2.8%, summaries in interlingua.
 14 PHYSICS IN MEDICINE AND BIOLOGY, 1956, Bristol, England, 2.8%, E, F, G, R.
 15 JOURNAL DE RADIOLOGIE, D'ELECTROLOGIE ET DE MEDECINE NUCLEAIRE, 1914, Paris, France, 2.7%, F, summaries in E.
 16 JAPANESE HEART JOURNAL, 1960, Tokyo, Japan, 2.6%, E.
 17 LYON MEDICAL, 1869, Lyon, France, 2.4%, F.
 18 IEEE. TRANSACTIONS: BIOMEDICAL ENGINEERING, 1954, Piscataway, N.J., 2.3%, E.
 19 ANNALES DE RADIOLOGIE: RADIOLOGIE CLINIQUE, RADIOBIOLOGIE, 1958, Paris, France, 2.1%, E, F.
 20 JOURNAL DE CHIRURGIE, 1908, Paris, France, 2.0%, E.
 21 COMPUTERS AND BIOMEDICAL RESEARCH, 1966, New York, U.S.A., 2.0%, E.
 22 MEDICAL AND BIOLOGICAL, ENGINEERING AND COMPUTING, 1963, Stevenage, England, 1.9%, E, F, G.
 23 JOURNAL D'UROLOGIE ET DE NEPHROLOGIE, 1912, Paris, France, 1.6%, F.
 24 ANNALES DE CHIRURGIE, 1947, Paris, France, 1.5%, E.
 25 JOURNAL OF BIOMEDICAL MATERIALS RESEARCH, 1966, New York, U.S.A., 1.4%, E.
 26 ACTA RADIOLOGICA SERIES 2: THERAPY, PHYSICS, BIOLOGY, 1921, Stockholm, Sweden, 1.4%, E.
 27 JOURNAL OF ELECTROCARDIOLOGY, 1968, San Diego, Cal., 1.3%, E.
 28 MODERN CONCEPTS OF CARDIOVASCULAR DISEASE, 1932, Dallas, Texas, 1.3%, E.
 29 RESPIRATION, 1944, Basel, Switzerland, 1.3%, E, F, G, summaries in F, G.
 30 ACTA CARDIOLOGICA, 1946, Brussels, Belgium, 1.2%, E, F.
 31 LYON CHIRURGICAL, 1908, Paris, France, 1.2%, F, summaries in E.
 32 REVUE DE CHIRURGIE ORTHOPEDIQUE ET REPARATRICE DE L'APPAREIL MOTEUR, 1908, Paris, France, 1.2%, F, summaries in E.
 33 COEUR ET MEDECINE INTERNE, 1962, Paris, France, 0.6%, F, E.

Speech and Hearing

- 6:57: 1 VISION RESEARCH, 1961, Elmsford, N.Y. and Oxford, England, 42.0%, E, F, G, R.
 2 ACOUSTICAL SOCIETY OF AMERICA, JOURNAL, 1929, New York, U.S.A., 40.1%, E.
 3 JOURNAL OF SPEECH AND HEARING RESEARCH, 1958, Washington, D.C., 7.2%, E.
 4 JOURNAL OF SPEECH AND HEARING DISORDERS, 1936, Washington, D.C., 6.1%, E.
 5 ACUSTICA, 1951, Stuttgart, West Germany, 3.7%, E.

Peripheral

- 10:58: 1 J EXP ANAL BEHAV

Peripheral

- 17:59: 1 WATER RESOUR RES
 2 J HYDRAUL DIV ASCE

Peripheral

- 25:60: 1 RESP PHYSIOL

LIST OF JOURNALS IN EACH FRONT - Continued

R.F.

Entomology

- 10:61: 1 JOURNAL OF INVERTEBRATE PATHOLOGY, 1959,
New York, U.S.A., 27.5%, E.
2 BULLETIN OF ENTOMOLOGICAL RESEARCH, 1910,
London, England, 24.0%, E.
3 ENTOMOLOGIA EXPERIMENTALIS APPLICATA, 1958,
Amsterdam, Netherlands, 16.3%, E, F, G,
summaries in language of country.
4 JOURNAL OF MEDICAL ENTOMOLOGY, 1964, Honolulu,
Hawaii, 13.0%, E.
5 MOSQUITO NEWS, 1940, Fresno, Cal., 12.4%, E.
6 ZEITSCHRIFT FUER ANGEWANDTE ENTOMOLOGIE/
JOURNAL OF APPLIED ENTOMOLOGY, 1914, Hamburg,
West Germany, 6.9%, E, F, G, abstracts in E.

Peripheral

- 27:62: 1 NEMATOLOGICA

Horticulture

- 10:63: 1 J AM SOC HORTIC SCI
2 HORTSCIENCE
3 J HORTIC SCI

Peripheral

- 28:64: 1 BRIT J VENER DIS

Mental Retardation

- 20:65: 1 AMERICAN JOURNAL OF MENTAL DEFICIENCY, 1940,
Albany, U.S.A., 19.0%, E.
2 EXCEPTIONAL CHILDREN, 1934, Reston, Va., 9.3%,
E.
3 JOURNAL OF CHILD PSYCHOLOGY AND PSYCHIATRY AND
ALLIED DISCIPLINES, 1960, 7.7%, E.
4 MERRILL-PALMER QUARTERLY OF BEHAVIOR AND
DEVELOPMENT, 1954, Detroit, Mich., 7.6%, E.
5 BRITISH JOURNAL OF EDUCATIONAL PSYCHOLOGY,
1931, Edinburgh, Scotland, 6.7%, E.
6 GENETIC PSYCHOLOGY MONOGRAPHS, 1926,
Provincetown, Mass., 6.5%, E.
7 MONOGRAPHS OF THE SOCIETY FOR RESEARCH IN CHILD
DEVELOPMENT, 1935, Washington, D.C., 6.3%, E.
8 JOURNAL OF LEARNING DISABILITIES, 1968,
Chicago, Ill., 5.8%, E.
9 HUMAN DEVELOPMENT, 1958, Basel, Switzerland,
5.8%, E.
10 AMERICAN ACADEMY OF CHILD PSYCHIATRY, JOURNAL,
1962, New Haven, Conn., 4.7%, E.
11 PHI DELTA KAPPAN, 1915, Bloomington, Indiana,
4.0%, E.
12 PSYCHOLOGY IN THE SCHOOLS, 1964, Brandon, Vt.,
3.7%, F.
13 EDUCATIONAL RESEARCH, 1958, Oxford, England,
3.7%, E.

India: Biology

- 18:66: 1 CURR SCI INDIA
2 INDIAN MED RES
3 P. INDIAN ACAD SCIE A
4 INDIAN J EXP BIOL

Japan: Biomedicine

- 21:67: 1 JPN J EXP MED
2 JPN J MED SCI BIOL

R.F.

Secondary Veterinary Science

- 22:68: 1 LABORATORY ANIMAL SCIENCE, 1950, Joliet, Ill.,
37.1%, E.
2 ACTA VETERINARIA SCANDINAVICA, 1959,
Copenhagen, Denmark, 14.5%, E, summaries in
Danish, E.
3 VETERINARY PATHOLOGY, 1964, Baltimore, Md.,
12.6%, E, G.
4 CANADIAN VETERINARY JOURNAL/REVUE VETERINAIRE
CANADIENNE, 1960, Ottawa, Canada, 8.0%, E.
5 NORDISK VETERINAEAMEDICIN/SCANDINAVIAN JOURNAL
OF VETERINARY SCIENCE, 1949, Copenhagen,
Denmark, 7.8%, Danish, E, Norwegian, Swedish.
6 VETERINARY MEDICINE/SMALL ANIMAL CLINICIAN,
1905, Bonner Springs, Kansas, 7.5%, E.
7 JOURNAL OF SMALL ANIMAL PRACTICE, 1960, Oxford,
England, 7.1%, E.
8 NEW ZEALAND VETERINARY JOURNAL, 1952,
Wellington, New Zealand, 6.3%, E.

Peripheral

- 29:69: 1 TERATOLOGY

Peripheral

- 30:70: 1 ANN BIOL ANIM BIOCH

Peripheral

- 31:71: 1 PAIN

Peripheral Biochemistry

- 23:72: 1 ACTA BIOLOGICA ET MEDICA GERMANICA, 1958,
Berlin, East Germany, 9.3%, E, F, G, R.
2 NEW YORK ACADEMY OF SCIENCES, TRANSACTIONS,
1881, New York, U.S.A., 8.8%, E.
3 TEXAS REPORTS ON BIOLOGY AND MEDICINE, 1943,
Galveston, Texas, 7.9%, E.
4 HARVEY LECTURES, 1953, New York, U.S.A., 7.0%,
E.
5 MEDICAL BIOLOGY, 1974, Helsinki, Finland, 5.9%,
E.
6 JOURNAL OF CYCLIC NUCLEOTIDE RESEARCH, 1975,
New York, U.S.A., 5.3%, E.
7 BIOFIZIKA, 1956, Moscow, U.S.S.R., 4.7%, R,
summaries in E.
8 FRONTIERS IN NEUROENDOCRINOLOGY, 1969,
Elmsford, N.Y. and Oxford, England, 3.9%, E.
9 ESSAYS IN BIOCHEMISTRY, 1965, London, England,
3.7%, E.
10 PHYSIOLOGIA BOHEMOSLAVACA, 1955, Prague,
Czechoslovakia, 3.7%, E included.
11 ACTA BIOCHIMICA POLONICA, 1954, Warsaw, Poland,
3.2%.
12 STUDIA BIOPHYSICA, 1966, Berlin, East Germany,
2.9%, G.
13 NEUROSCIENCE LETTERS, 1975, Limerick, Ireland,
2.9%, E.
14 INTERNATIONAL JOURNAL OF PEPTIDE AND PROTEIN
RESEARCH, 1968, Copenhagen, Denmark, 2.9%, E.
15 CURRENT TOPICS IN MEMBRANES AND TRANSPORT,
1970, New York, U.S.A., 2.8%, E.
16 PSYCHOPHARMACOLOGY, 1959, New York, U.S.A.,
2.7%, mainly E.
17 CURRENT TOPICS IN BIOENERGETICS,* 1971,
New York, U.S.A., 2.6%, E.
18 PROGRESS IN NEUROBIOLOGY, 1973, Oxford,
England, 2.5%, E.

LIST OF JOURNALS IN EACH FRONT - Concluded

R.F.

Peripheral Biochemistry - Concluded

- 23:72:19 NEUROSCIENCE, 1976, Elmsford, N.Y. and Oxford, England, 2.3%, E.
 20 NEUROSCIENCES RESEARCH PROGRAM, BULLETIN, 1963, Cambridge, Mass., 2.3%, E.
 21 TSITOLOGIYA, 1959, Leningrad, U.S.S.R., 2.2%, R, summaries and content in E.
 22 SUB-CELLULAR BIOCHEMISTRY, 1971, London, England and New York, U.S.A., 2.2%, E.
 23 TRENDS IN BIOCHEMICAL SCIENCES, 1976, Amsterdam, Netherlands, 1.8%, E.
 24 MOLECULAR BIOLOGY, 1967 (English Edition of MOLEKULYAVNAYA BIOLOGIA, U.S.S.R.), New York, U.S.A., 1.7%, E.
 25 GENETIKA' 1965, Moscow, U.S.S.R., 1.7%, R, E.
 26 ENDOCRINE RESEARCH COMMUNICATIONS, 1974, New York, U.S.A., 1.7%, E.
 27 ACTA NEUROBIOLOGIAE EXPERIMENTALIS, 1928, Warsaw, Poland, 1.6%, E, content page in P, R, E.
 28 INTERNATIONAL JOURNAL OF NEUROSCIENCE, 1970, London, England, 1.4%, E.
 29 BIOORGANICHESKAYA KHIMIYA, 1975, Moscow, U.S.S.R., 0.9%, R, summaries in E.

Peripheral

- 24:73: 1 WEED SCI
 2 WEED RES

Peripheral

- 32:74: 1 T ASAE

Peripheral

- 26:75: 1 AUST J EXP AGR ANIM

Peripheral

- 33:76: 1 J AM DIET ASSOC

Peripheral

- 7:77: 1 SOV PHYS SEMICOND

Peripheral

- 34:78: 1 RADIOTEKH ELEKTRON

Materials Science, Metallurgy

- 7:79: 1 FIZIKA METALLOV I METALLOVEDENIE, 1955, Moscow, U.S.S.R., 24.3%, R.
 2 ARCHIV FUR DAS EISENHUETTEN WESEN, 1927, Dusseldorf, West Germany, 13.8%, G.
 3 JOURNAL OF METALS, 1977, New York, U.S.A., 11.3%, E.
 4 CORROSION SCIENCE, 1961, Elmsford, N.Y. and Oxford, England, 9.9%, E.
 5 JAPAN INSTITUTE OF METALS, TRANSACTIONS, 1960, Sandai, Japan, 9.2%, E.
 6 CORROSION, SCIENTIFIC DATA ON CORROSION AND CONTROL, 1945, Houston, Texas, 7.5%, E.
 7 REVUE DE METALLURGIE, MEMOIRES SCIENTIFIQUES, 1904, Paris, France, 5.6%.
 8 PROGRESS IN MATERIALS SCIENCE, 1949, Elmsford, N.Y. and Oxford, England, 4.8%.

R.F.

- 7:79: 9 JAPAN INSTITUTE OF METALS, JOURNAL, 1937, Sendai, Japan, 4.3%, J, contents page and summaries in E.
 10 IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENII SERIYA FIZIKA, 1957, Tomsk, U.S.S.R., 3.9%, R, contents page in E.
 11 OXIDATION OF METALS, 1969, New York, U.S.A., 2.8%.
 12 CANADIAN METALLURGICAL QUARTERLY, 1962, Elmsford, N.Y. and Oxford, England, 2.7%, E.

Peripheral

- 35:80: 1 VACUUM

Secondary Geology

- 9:81: 1 ECONOMIC GEOLOGY AND THE BULLETIN OF THE SOCIETY OF ECONOMIC GEOLOGISTS, 1906, Duluth, Minn., 17.5%, E.
 2 SOCIETE FRANCAISE DE MINERALOGIE ET DE CRISTALLOGRAPHIE, BULLETIN, 1878, Paris, France, 10.1%, F.
 3 MINERALOGICAL MAGAZINE, 1876, London, England, 9.4%, E.
 4 MARINE GEOLOGY, 1964, Amsterdam, Netherlands, 9.1%, E, F, G.
 5 GEOLOGICAL MAGAZINE, 1864, Cambridge, England, 8.5%, F.
 6 CHEMICAL GEOLOGY, 1966, Amsterdam, Netherlands, 7.9%, E, F, G.
 7 JOURNAL OF PALEONTOLOGY, 1927, Oklahoma, U.S.A., 7.7%, E.
 8 SEDIMENTOLOGY, 1952, Oxford, England, 6.7%, E, F, G.
 9 QUATERNARY RESEARCH, 1970, New York, U.S.A. and London, England, 6.4%, E, F, G, R.
 10 LITHOS, 1968, Oslo, Norway, 4.6%, E.
 11 PALAEOGEOGRAPHY, PALAEOCLIMATOLOGY, PALAEOECOLOGY, 1965, Amsterdam, Netherlands, 3.7%, E, F, G.
 12 EARTH SCIENCE REVIEWS, 1966, Amsterdam, Netherlands, 3.6%.
 13 NEW ZEALAND JOURNAL OF GEOLOGY AND GEOPHYSICS, 1958, Wellington, New Zealand, 2.7%, E.
 14 LETHAIA, AN INTERNATIONAL JOURNAL OF PALEONTOLOGY AND STRATIGRAPHY, 1968, Oslo, Norway, 2.3%, E.

Secondary Probability

- 14:82: 1 Z WAHRSCHEINLICHKEIT
 2 ANN PROBAB
 3 J APPL PROBAB

Russia: Peripheral Chemistry

- 7:83: 1 UKR KHIM ZH
 2 ZH VSES KHIM OVA
 3 VESTN MOSK U KHIM

Peripheral

- 36:84: 1 THERMOCHIM ACTA

Textiles

- 19:85: 1 TEXT RES J
 2 J SOC DYERS COLOUR

Appendix V

TABLES

TABLE 1. International Shares of Relevance for Peripheral Medical Research Fronts,
1978 Reference Year

Research front/country	Share of relevant papers(1)	Share of relevance	Share of top decile relevance	Share of top percentile relevance
	per cent			
Secondary biochemistry (R.F.2:12)				
1 United States	54.8	53.6	54.3	47.6
2 England	9.8	11.1	10.7	5.8
3 Canada	9.2	8.6	7.9	11.2
4 West Germany	5.2	5.3	4.7	4.1
5 France	2.7	3.0	3.2	6.3
6 Japan	2.6	2.2	2.0	3.0
7 Netherlands	1.9	2.0	2.3	1.1
8 Australia	1.8	1.1	0.3	--
9 Sweden	1.5	1.1	0.7	--
10 Scotland	1.4	0.7	0.3	--
Microbiology and macromolecular science (R.F.2:15)				
1 United States	37.1	39.3	39.6	31.2
2 Japan	10.6	10.2	11.0	13.7
3 England	8.3	12.0	13.2	17.7
4 West Germany	6.9	6.2	5.6	6.2
5 France	6.8	7.0	7.7	9.8
6 Canada	6.3	4.7	2.9	3.0
7 Italy	3.4	1.7	1.0	--
8 U.S.S.R.	3.0	1.9	1.4	3.0
9 Netherlands	2.1	2.5	2.7	1.5
10 Scotland	1.5	1.7	1.5	--
11 Czechoslovakia	1.4	1.2	1.1	--
12 Belgium	1.4	1.3	1.3	1.5
13 Australia	1.4	1.6	2.0	--
14 India	1.3	0.8	0.5	--
15 Poland	1.0	1.0	1.2	1.6
16 Sweden	1.0	2.0	2.8	9.2
Nutrition, clinical medicine and public health (R.F.2:19)				
1 United States	51.4	44.2	41.5	21.7
2 West Germany	9.4	11.3	12.0	20.2
3 England	7.3	11.9	14.7	23.8
4 Australia	4.5	4.9	5.1	5.9
5 Switzerland	3.6	4.2	4.0	6.9
6 South Africa	3.5	2.8	2.6	3.7
7 Sweden	3.0	2.9	2.5	1.5
8 Canada	2.6	2.7	2.7	1.8
9 Scotland	1.6	2.0	1.9	3.8
10 Denmark	1.0	0.9	0.6	--

See footnote(s) at end of table.

TABLE 1. International Shares of Relevance for Peripheral Medical Research Fronts,
1978 Reference Year - Continued

Research front/country	Share of relevant papers(1)	Share of relevance	Share of top decile relevance	Share of top percentile relevance
	per cent			
Ecology (R.F.2:21)				
1 United States	64.4	66.2	68.6	72.6
2 Canada	19.5	18.9	17.3	9.8
3 England	5.2	5.7	5.2	--
4 West Germany	1.2	1.7	1.9	6.2
5 France	1.0	0.6	0.7	--
6 Scotland	0.9	1.2	1.4	3.8
7 Australia	0.8	1.3	1.2	6.6
Secondary biochemistry, human genetics (R.F.2:24)				
1 United States	33.9	38.1	39.5	33.4
2 England	12.1	15.4	17.8	23.4
3 France	9.2	5.9	4.6	2.1
4 West Germany	5.8	4.4	3.9	1.9
5 Canada	4.7	3.9	2.9	1.2
6 Sweden	4.5	6.6	8.3	11.1
7 Scotland	2.7	2.6	2.0	0.7
8 Denmark	2.7	2.2	1.8	1.5
9 Japan	2.3	2.5	3.0	7.0
10 Italy	2.2	1.3	1.3	--
11 Belgium	2.1	1.4	0.6	--
12 Switzerland	2.0	1.1	1.1	0.7
13 Netherlands	1.9	1.8	1.8	1.6
14 Australia	1.8	2.3	2.5	1.8
15 Finland	1.6	1.4	1.2	0.6
16 Israel	1.5	1.5	1.7	2.5
Psychiatry, psychology (R.F.2:26)				
1 United States	73.3	78.6	87.4	88.3
2 England	10.6	8.2	4.8	4.6
3 Canada	4.5	4.2	3.8	3.9
4 Denmark	2.3	1.8	0.4	--
6 Scotland	2.0	1.2	--	--
5 Sweden	1.5	1.1	--	--
7 Israel	0.5	0.7	0.9	2.5
Immunology and allergies (R.F.2:27)				
1 United States	49.4	58.1	54.7	50.6
2 England	10.2	9.6	8.2	5.3
3. Israel	4.2	2.0	1.6	4.4
4. West Germany	3.7	3.4	2.8	1.7

See footnote(s) at end of table.

TABLE 1. International Shares of Relevance for Peripheral Medical Research Fronts,
1978 Reference Year - Continued

Research front/country	Share of relevant papers(1)	Share of relevance	Share of top decile relevance	Share of top percentile relevance
	per cent			
Immunology and allergies (R.F.2:27) -				
Concluded				
5 Sweden	3.7	4.9	4.1	3.6
6 France	3.1	3.5	3.9	3.7
7 Australia	2.9	2.7	2.0	--
8 Canada	2.7	2.6	2.5	2.6
9 Netherlands	2.3	2.1	1.5	--
10 Denmark	1.5	2.1	4.1	8.7
11 Scotland	1.8	1.2	1.2	2.1
12 Switzerland	1.6	1.5	1.3	--
13 Norway	1.6	2.0	2.0	2.9
14 Japan	1.5	1.8	2.5	4.9
15 Italy	1.4	0.9	0.6	4.9
16 Finland	1.1	1.3	1.5	1.8
17 Austria	1.0	1.0	1.2	--
General clinical medicine (R.F.2:36)				
1 United States	35.5	32.5	32.3	33.3
2 France	27.1	24.5	25.5	20.9
3 England	6.8	12.3	14.6	24.4
4 Japan	4.3	4.0	3.7	5.7
5 West Germany	3.8	4.5	3.7	5.7
6 Sweden	3.3	2.8	2.0	--
7 Canada	3.0	3.3	3.1	1.0
8 Denmark	2.2	1.7	1.3	--
9 Italy	1.9	2.0	2.1	1.0
10 Norway	1.5	1.4	0.9	--
11 Belgium	1.3	1.4	1.7	--
12 Netherlands	1.1	1.7	1.9	2.4
13 Scotland	1.0	0.9	1.0	--
14 Switzerland	1.0	0.9	0.6	--
Applied microbiology, biotechnology (R.F.2:39)				
1 United States	31.7	37.4	43.3	61.7
2 Japan	31.3	24.3	19.4	10.8
3 England	5.2	6.3	7.0	4.9
4 Canada	4.4	5.6	5.6	2.8
5 Belgium	3.7	2.4	0.7	--
6 France	3.1	3.4	4.5	1.5
7 Sweden	2.5	3.4	4.5	3.5
8 West Germany	1.9	1.9	2.2	3.2
9 Italy	1.7	0.7	0.5	--
10 Netherlands	1.7	2.0	1.8	2.4
11 Scotland	1.1	1.0	0.9	--

See footnote(s) at end of table.

TABLE 1. International Shares of Relevance for Peripheral Medical Research Fronts,
1978 Reference Year - Concluded

Research front/country	Share of relevant papers(1)	Share of relevance	Share of top decile relevance	Share of top percentile relevance
	per cent			
Clinical pharmacology, geriatrics (R.F.2:43)				
1 United States	34.3	32.3	30.2	37.5
2 England	14.0	17.1	18.5	18.2
3 Japan	7.5	3.2	2.2	5.8
4 Australia	5.6	5.7	5.7	5.9
5 Canada	5.4	3.9	3.0	--
6 New Zealand	4.9	5.6	6.4	5.3
7 France	4.5	4.2	5.1	3.3
8 Sweden	4.0	5.4	5.4	5.9
9 Italy	3.2	2.5	2.2	--
10 Scotland	3.2	2.5	2.2	--
11 West Germany	2.9	5.1	7.1	8.9
12 Switzerland	1.8	2.2	2.5	6.4
13 Belgium	1.2	1.3	1.3	--
14 Netherlands	1.0	1.3	2.0	--
15 Denmark	1.0	1.4	1.2	--
Clinical medicine, reproductive biology (R.F.2:46)				
1 United States	28.6	27.3	24.3	22.3
2 England	11.5	14.4	17.8	18.1
3 France	8.3	6.4	5.1	6.2
4 West Germany	8.2	8.4	8.6	13.1
5 Sweden	5.9	7.5	9.6	9.2
6 Canada	3.1	3.2	2.9	4.3
7 Japan	3.0	2.3	1.5	--
8 Denmark	2.2	2.1	2.1	6.9
9 Italy	2.2	1.4	1.2	--
10 Belgium	2.1	1.9	1.7	--
11 India	2.0	1.6	0.8	--
12 Netherlands	2.0	3.0	4.0	1.9
13 Israel	1.8	1.1	0.7	--
14 U.S.S.R.	1.8	1.8	1.7	--
15 Scotland	1.8	1.7	1.3	2.2
16 Australia	1.7	2.5	2.9	6.1
17 Finland	1.6	1.9	2.4	3.2
18 Czechoslovakia	1.5	1.5	1.0	--
19 Switzerland	1.5	1.5	1.0	--
20 East Germany	1.2	1.1	1.3	--

(1) The addresses of relevant papers dated 1974, 1975 or 1976 were searched in the 74 to 76 corporate tapes, and those countries with at least 1% of fractionally allocated addresses are shown.

TABLE 2. International Shares of Relevance in Applied Mathematics, Secondary Physical Applications (R.F.6:30), 1978 Reference Year

Country	Share of relevant papers(1)	Share of relevance	Share of top decile relevance	Share of top percentile relevance
	per cent			
1 United States	47.6	56.1	60.6	82.4
2 England	9.0	9.7	8.8	3.8
3 France	7.3	7.2	7.1	3.2
4 West Germany	7.2	5.3	4.6	--
5 Japan	4.5	2.7	2.6	--
6 Canada	3.4	2.3	1.4	--
7 Italy	1.8	2.1	3.2	7.0
8 India	1.7	0.9	0.4	--
9 Israel	1.6	1.2	1.2	--
10 U.S.S.R.	1.6	1.5	1.5	0.8
11 Netherlands	1.6	1.3	1.5	0.4
12 Australia	1.5	1.4	1.3	1.5
13 Switzerland	1.5	0.9	0.5	--
14 Denmark	1.3	1.1	0.9	--
15 Sweden	1.1	0.8	0.6	--

(1) The addresses of relevant papers dated 1974, 1975 or 1976 were searched in the 74 to 76 corporate tapes, and those countries with at least 1% of fractionally allocated addresses are shown.

TABLE 3. International Shares of Relevance in Applied Engineering Research Fronts, 1978 Reference Year

Research front/country	Share of relevant papers(1)	Share of relevance	Share of top decile relevance	Share of top percentile relevance
	per cent			
Chemical engineering (R.F.7:34)				
1 United States	26.6	25.4	25.3	24.0
2 Japan	9.1	8.8	8.7	6.6
3 India	9.0	9.4	10.5	12.3
4 West Germany	8.1	8.5	8.3	8.8
5 Poland	6.9	5.6	5.3	4.6
6 East Germany	6.5	6.2	5.0	2.3
7 Canada	5.2	6.4	5.9	4.1
8 England	4.7	5.3	5.3	6.0
9 Italy	3.4	3.4	4.1	2.0
10 Hungary	3.3	2.2	2.3	2.7
11 Switzerland	2.1	2.2	2.3	2.7
12 Belgium	1.7	1.8	1.4	--
13 France	1.7	2.0	2.0	2.0
14 Israel	1.5	1.3	1.1	--
15 U.A.R.	1.6	1.3	1.1	--
16 Netherlands	1.3	1.2	1.2	--
17 Australia	0.9	2.9	4.2	11.2
Photo-chemistry, applied physics (R.F.7:41)				
1 United States	36.5	39.2	38.9	41.4
2 West Germany	14.4	16.7	17.5	19.6
3 England	7.1	8.7	9.1	5.1
4 France	6.8	3.0	2.0	--
5 Japan	5.5	1.6	0.8	--
6 Netherlands	3.7	4.5	5.2	1.6
7 Canada	3.7	5.1	5.2	6.1
8 U.S.S.R.	3.5	2.7	2.9	6.5
9 India	2.0	1.3	1.2	1.5
10 Switzerland	1.7	1.0	0.8	--
11 Italy	1.6	1.5	1.5	--
12 Poland	1.5	1.8	1.9	4.3
13 Israel	1.2	1.2	1.0	1.3
14 Australia	1.1	3.8	4.5	4.8

(1) The addresses of relevant papers dated 1974, 1975 or 1976 were searched in the 74 to 76 corporate tapes, and those countries with at least 1% of fractionally allocated addresses are shown.

TABLE 4. International Shares of Relevance in Geology and Astrophysics (R.F.8:13), 1978 Reference Year

Country	Share of relevant papers(1)	Share of relevance	Share of top decile relevance	Share of top percentile relevance
	per cent			
1 United States	60.0	62.8	67.4	75.7
2 England	7.3	9.3	10.3	10.1
3 Canada	6.4	4.7	3.0	1.2
4 France	4.3	3.9	3.6	2.9
5 West Germany	3.8	4.0	3.7	0.6
6 Australia	3.3	3.8	3.4	7.8
7 Netherlands	1.8	2.4	2.9	--
8 Italy	1.7	1.0	0.6	--
9 Japan	1.0	0.6	0.3	--
10 Scotland	0.9	0.7	0.2	0.6
11 Chile	0.9	0.6	0.4	--
12 U.S.S.R.	0.8	0.8	0.8	--
13 A.R.S.S.R.	-	0.1	0.1	0.6

(1) The addresses of relevant papers dated 1974, 1975 or 1976 were searched in the 74 to 76 corporate tapes, and those countries with at least 1% of fractionally allocated addresses are shown.

TABLE 5. International Shares of Relevance in Physics of Materials (R.F.9:23), 1978 Reference Year

Country	Share of relevant papers(1)	Share of relevance	Share of top decile relevance	Share of top percentile relevance
	per cent			
1 United States	21.3	24.0	24.3	15.2
2 England	13.6	17.4	18.5	19.6
3 France	11.4	9.0	8.0	13.6
4 West Germany	9.7	9.8	9.9	9.7
5 U.S.S.R.	7.0	6.1	5.9	2.4
6 Japan	6.6	5.3	5.4	6.1
7 Italy	5.5	3.9	4.0	1.1
8 Sweden	3.0	4.9	5.9	19.0
9 Switzerland	2.6	2.2	2.1	2.0
10 Netherlands	2.4	3.4	4.0	5.0
11 India	2.3	1.7	1.4	--
12 Canada	6.4	4.7	3.0	1.2
13 Australia	1.8	1.6	1.4	--

(1) The addresses of relevant papers dated 1974, 1975 or 1976 were searched in the 74 to 76 corporate tapes, and those countries with at least 1% of fractionally allocated addresses are shown.

TABLE 6. International Shares of Relevance in Applied Statistics, Population Biology (R.F.10:50), 1978 Reference Year

Country	Share of relevant papers(1)	Share of relevance	Share of top decile relevance	Share of top percentile relevance	Country	Share of relevant papers(1)	Share of relevance	Share of top decile relevance	Share of top percentile relevance
	per cent					per cent			
1 United States	38.4	45.0	49.9	55.1	9 Sweden	2.3	1.3	0.7	--
2 West Germany	12.2	12.3	11.1	6.9	10 France	1.8	1.0	0.9	2.8
3 Canada	7.6	8.5	8.3	7.0	11 Australia	1.8	2.7	3.3	3.4
4 England	7.5	9.1	10.2	15.7	12 Israel	1.3	0.9	0.5	--
5 Japan	5.7	1.8	0.5	--	13 Italy	1.2	0.5	0.3	--
6 Austria	4.6	3.0	2.7	3.7	14 Netherlands	1.2	0.5	0.3	--
7 Scotland	2.6	2.9	2.6	--	15 Denmark	1.1	1.5	1.7	4.3
8 Switzerland	2.5	2.1	1.3	--	16 New Zealand	1.1	1.1	0.4	--

(1) The addresses of relevant papers dated 1974, 1975 or 1976 were searched in the 74 to 76 corporate tapes, and those countries with at least 1% of fractionally allocated addresses are shown.

TABLE 7. Canadian Institutions in the Top Decile of Relevance by Research Front, 1978 Reference Year

Research front/ rank	Institution(1)	Frequency in top decile	Rank in top percentile	Frequency in top percentile	Research front/ rank	Institution(1)	Frequency in top decile	Rank in top percentile	Frequency in top percentile
R.F.					R.F.				
1: 1: 1	University of Toronto	40	2	4	1: 2:10	University of Alberta	14	8	1
2	McGill University	18	1	1	11	Queen's University at Kingston	10	--	--
3	University of British Columbia	13	--	--	12	Dalhousie University	6	--	--
4	Sick Children's Hospital, Toronto	12	--	--	13	University of Saskatchewan	3	--	--
5	National Research Council, Ottawa	12	3	2	14	Clarke Institute of Psychiatry, Toronto	8	--	--
6	Université de Montréal	9	5	1	15	Université Laval	4	7	1
7	University of Guelph	7	7	1	16	Children's Hospital, Montréal	5	--	--
8	University of Manitoba	11	--	--	17	Montreal Heart Institute	9	10	3
9	McMaster University	9	--	--	18	Université Laval Centre Hospital, Québec City	7	--	--
10	Université Laval	8	--	--	19	Ontario Cancer Institute, Toronto	2	6	1
11	Ontario Cancer Institute, Toronto	6	6	1	20	Health Science Centre, Winnipeg	4	--	--
12	University of Western Ontario	6	--	--	21	University of Western Ontario	4	--	--
13	Atomic Energy of Canada Ltd., Chalk River, Ontario	5	4	5	22	Kingston General Hospital	2	--	--
14	University of Alberta	4	--	--	23	Dept. of Agriculture, Ottawa ..	2	--	--
15	Memorial University of Newfoundland	3	--	--	24	University of Calgary	2	9	1
16	University of Saskatchewan	5	--	--	25	Université de Sherbrooke	1	--	--
17	York University	4	--	--	26	University Hospital, London, Ontario	3	--	--
18	National Research Council, Saskatoon	2	--	--	27	University of Waterloo	1	--	--
19	Royal Victoria Hospital, Montréal	3	--	--	28	Hotel Dieu, Montréal	1	--	--
20	Queen's University at Kingston	2	--	--	29	St. Joseph's Hospital, Hamilton	3	--	--
21	Jewish General Hospital, Montréal	2	--	--	30	Toronto General Hospital	2	--	--
22	Université Laval Centre Hospital, Québec City	1	--	--	31	Memorial University of Newfoundland	3	--	--
23	Sherbrooke Medical Centre	2	--	--	32	St. John's General Hospital ..	1	--	--
24	Dalhousie University	2	--	--	33	Trent University	1	--	--
25	Queen Mary Vet. Hospital, Montréal	3	--	--	34	Queen Mary Vet. Hospital, Montréal	1	--	--
26	University of Ottawa	1	--	--	35	Windsor Clinic, Windsor	1	--	--
27	Ayerst Labs., Montréal	1	--	--	36	Hotel Dieu, Windsor	1	--	--
28	Dept. of National Defence, Toronto	1	--	--	37	Douglas Hospital, Montréal	1	--	--
29	University of Calgary	1	--	--	38	Canadian Red Cross, Toronto ..	1	--	--
30	Montreal General Hospital	1	--	--	39	WW Cross Cancer Institute, Edmonton	1	--	--
31	University of Victoria, Victoria	1	--	--	40	Atomic Energy Canada Ltd., Pinawa, Manitoba	1	--	--
32	Sunnybrook Hospital, Toronto	1	--	--	41	Simon Fraser University	1	--	--
1: 2: 1	University of British Columbia	32	1	5	1: 5: 1	McGill University	7	1	1
2	University of Manitoba	25	3	3	2	University of Toronto	23	4	2
3	McGill University	22	--	--	3	University of British Columbia	12	--	--
4	University of Toronto	31	--	--	4	University of Saskatchewan	7	3	1
5	Université de Montréal	12	4	1	5	Queen's University at Kingston	9	2	4
6	Montreal General Hospital	12	--	--	6	Sick Children's Hospital, Toronto	12	--	--
7	McMaster University	18	--	--	7	University of Manitoba	6	--	--
8	Sick Children's Hospital, Toronto	8	5	3	8	University of Ottawa	7	--	--
9	Royal Victoria Hospital, Montréal	10	2	3	9	Royal Victoria Hospital, Montréal	9	--	--
					10	McMaster University	3	--	--
					11	University of Western Ontario	3	--	--
					12	Université de Montréal	2	--	--

See Footnote(s) at end of table.

TABLE 7. Canadian Institutions in the Top Decile of Relevance by Research Front, 1978 Reference Year - Continued

Research front/ rank	Institution(1)	Fre- quency in top decile	Rank in top per- centile	Fre- quency in top per- centile	Research front/ rank	Institution(1)	Fre- quency in top decile	Rank in top per- centile	Fre- quency in top per- centile
R.F.					R.F.				
1: 5:13	Addiction Research Foundation, Toronto	3	-	-	1: 8: 1	University of Toronto	28	3	1
14	University of Calgary	2	-	-	2	University of Guelph	4	1	3
15	Ontario Cancer Institute, Toronto	1	5	1	3	McGill University	7	2	1
16	University of Alberta	2	-	-	4	University of Manitoba	17	-	-
17	Ayerst Labs., Montréal	1	-	-	5	University of Alberta	14	-	-
18	Université de Sherbrooke Centre Hospital	1	-	-	6	University of British Columbia	9	-	-
19	Medical Research Council, Ottawa	1	-	-	7	Royal Victoria Hospital, Montréal	8	-	-
20	Notre Dame Hospital, Montréal	1	-	-	8	Université Laval	8	-	-
21	University of Windsor	1	6	1	9	Toronto General Hospital	5	-	-
22	St. Boniface General Hospital, Winnipeg	1	-	-	10	Sick Children's Hospital, Toronto	7	-	-
23	Children's Hospital, Montréal	1	-	-	11	McMaster University	7	-	-
24	Toronto Western Hospital	2	-	-	12	Hotel Dieu, Kingston	3	-	-
1: 6: 1	University of Toronto	17	5	2	13	Memorial University of Newfoundland	5	-	-
2	University of British Columbia	8	1	3	14	University of Western Ontario	3	-	-
3	McGill University	12	-	-	15	Children's Hospital, Montréal	3	-	-
4	Université Laval	5	3	2	16	University of Waterloo	1	-	-
5	University of Alberta	6	-	-	17	Queen's University at Kingston	5	-	-
6	Ontario Cancer Institute, Toronto	6	-	-	18	Wellesley Hospital, Toronto ...	3	-	-
7	Université Laval Centre Hos- pital, Québec City	4	2	3	19	University Hospital of London	2	-	-
8	National Research Council, Ottawa	4	-	-	20	Montréal General Hospital	2	-	-
9	McMaster University	2	-	-	21	University of Windsor	2	-	-
10	Queen's University at Kingston	7	-	-	22	Hotel Dieu, Québec City	2	-	-
11	University of Western Ontario	3	-	-	23	University of Calgary	1	-	-
12	University of Waterloo	2	-	-	24	Merck Frosst Labs., Montréal ..	2	-	-
13	Ontario Cancer Foundation, Kingston	2	4	1	25	University of Alberta Hospital	1	-	-
14	B.C. Cancer Institute, Vancouver	1	-	-	26	Queen Mary Vet. Hospital, Montréal	1	-	-
15	Dalhousie University	5	-	-	27	St. Michael's Hospital, Toronto	1	-	-
16	Université de Sherbrooke	3	-	-	28	University of Saskatchewan	2	-	-
17	University of Ottawa	3	-	-	29	Queen Mary Vet. Hospital, St. John's	2	-	-
18	Université de Montréal	1	-	-	30	Dalhousie University	1	-	-
19	Sick Children's Hospital, Toronto	2	-	-	31	Camp Hill Hospital, Halifax ...	1	-	-
20	University of Manitoba	4	-	-	32	Notre Dame Hospital, Montréal	1	-	-
21	Montreal General Hospital	1	-	-	33	Children's Hospital, Winnipeg	1	-	-
22	Simon Fraser University	1	-	-	34	Health Science Centre, Winnipeg	1	-	-
23	Henderson General Hospital, Hamilton	1	-	-	35	Halifax General Hospital	1	-	-
24	Kingston General Hospital	1	-	-	36	Dept. of Agriculture, Saskatoon	1	-	-
25	University of Guelph	1	-	-	37	St. Justine Hospital, Montréal	1	-	-
26	Manitoba Cancer Foundation, Winnipeg	1	-	-	38	Mt. Sinai Hospital, Toronto ...	1	-	-
1: 7: 1	University of Toronto	16	-	-	39	Sunnybrook Hospital, Toronto ..	1	-	-
2	University of British Columbia	7	3	2	40	Ottawa General Hospital	1	-	-
3	St. Luc Hospital, Montréal	20	-	-	41	Ottawa Civic Hospital	1	-	-
4	Université de Montréal	9	2	3	2:12: 1	Université de Sherbrooke	4	1	1
5	Toronto General Hospital	6	-	-	2	University of Toronto	12	2	2
6	Sick Children's Hospital, Toronto	8	-	-	3	Université Laval	10	6	1
7	University of Alberta	3	-	-	4	University of Alberta	7	-	-
8	McMaster University	3	-	-	5	University of Waterloo	8	-	-
9	Dalhousie University	4	1	4	6	University of Calgary	5	-	-
10	Queen's University at Kingston	5	-	-	7	Carleton University	4	3	1
11	McGill University	3	-	-	8	Sick Children's Hospital, Toronto	3	5	1
12	Montréal Heart Institute	3	5	1	9	University of Western Ontario	4	4	2
13	WW Cross Cancer Institute, Edmonton	2	-	-	10	University of British Columbia	5	-	-
14	Shaughnessy DVA Hospital, Vancouver	1	4	1	11	Memorial University of Newfoundland	2	-	-
15	Kingston General Hospital	1	-	-	12	York University	2	-	-
16	Notre Dame Hospital, Montréal	1	-	-	13	Concordia University	1	-	-
17	St. Joseph's Hospital, Toronto	1	-	-	14	Queen's University at Kingston	2	-	-
18	Université Laval	1	-	-	15	Ontario Cancer Institute, Toronto	1	7	1
19	Canadian Red Cross, Toronto ...	1	-	-	16	Université Laval Centre Hos- pital, Québec City	1	8	1
20	Victoria Hospital, Halifax	1	6	1	17	Simon Fraser University	1	9	1
21	Royal Victoria Hospital, Montréal	1	-	-	18	McMaster University	1	-	-
22	Dept. of National Defence, Toronto	1	-	-	19	University of Ottawa	3	-	-
23	Mt. Sinai Hospital, Toronto ...	1	-	-	20	Jewish General Hospital, Montréal	1	-	-
24	University of Guelph	1	-	-	21	University of Guelph	1	-	-
25	Hotel Dieu, Kingston	1	-	-	22	Dept. of Environment, Winnipeg	1	-	-
26	Toronto Western Hospital	1	-	-	23	Sudbury Algoma Sanatorium	1	-	-
					24	Laurentian University of Sudbury	1	-	-
					2:15: 1	National Research Council, Ottawa	5	1	1
					2	University of British Columbia	7	-	-
					3	University of Waterloo	2	2	2
					4	University of Calgary	3	-	-
					5	McGill University	4	-	-

See footnote(s) at end of table.

TABLE 7. Canadian Institutions in the Top Decile of Relevance by Research Front, 1978 Reference Year - Continued

Research front/ rank	Institution(1)	Fre- quency in top decile	Rank in top per- centile	Fre- quency in top per- centile	Research front/ rank	Institution(1)	Fre- quency in top decile	Rank in top per- centile	Fre- quency in top per- centile
R.F.					R.F.				
2:15: 6	Université Laval	3	-	-	2:21:31	Dept. of Environment, Montréal	1	-	-
7	University of Toronto	3	-	-	32	Brock University	2	-	-
8	École Polytechnique, Montréal	6	-	-	33	Sweltzer Creek Salmon Res.			
9	Simon Fraser University	1	-	-		Lab., Cultus Lake, B.C.	2	-	-
10	Health and Welfare Canada,				34	Dept. of Environment, Edmonton	1	-	-
	Ottawa	3	-	-	35	Concordia University	1	-	-
11	Dept. of Agriculture,				36	Université de Montréal	1	-	-
	Lethbridge	1	-	-	37	Dept. of Environment,			
12	University of Western Ontario	1	-	-		St. John's	1	-	-
13	Pulp and Paper Research								
	Institute, Montréal	1	-	-					
R.F.					R.F.				
2:19: 1	McGill University	10	-	-	2:24: 1	National Research Council,			
2	University of Guelph	9	-	-		Ottawa	4	-	-
3	Sick Children's Hospital,				2	University of Toronto	2	-	-
	Toronto	8	2	1	3	Sick Children's Hospital,			
4	University of British Columbia	3	1	1		Toronto	1	1	1
5	Health and Welfare Canada,				4	Memorial University of			
	Ottawa	4	-	-		Newfoundland	7	-	-
6	McMaster University	5	-	-	5	York University	2	-	-
7	Unknown, Toronto	1	3	1	6	McGill University	3	-	-
8	University of Toronto	4	-	-	7	Ayerst Labs., Montréal	1	-	-
9	Dept. of Agriculture, Ottawa	5	-	-	8	University of Manitoba	2	-	-
10	University of Alberta	3	-	-	9	Health Science Centre, Winnipeg	2	-	-
11	University of Saskatchewan	2	-	-	10	University of Western Ontario	2	-	-
12	Royal Victoria Hospital,				11	University of British Columbia	2	-	-
	Montréal	2	-	-	12	Dr. CA Janeway Child Health			
13	York University	1	-	-		Centre, St. John's	1	-	-
14	University of Manitoba	1	-	-	13	University of Guelph	1	-	-
15	Health Science Centre, Winnipeg	1	-	-	14	McMaster University	1	-	-
16	Montréal Heart Institute	4	-	-	15	Université Laval Centre Hos-			
17	Dept. of Agriculture,					pital, Québec City	1	-	-
	Lennoxville, Québec	1	-	-	16	Enfant Jesus Hospital,			
18	St. Justine Hospital, Montréal	1	-	-		Québec City	1	-	-
19	Université de Montréal	1	-	-	17	Dept. of Agriculture, Ottawa ..	1	-	-
20	Jewish General Hospital,				18	National Research Council,			
	Montréal	1	-	-		Saskatoon	1	-	-
21	Ottawa General Hospital	1	-	-	19	Royal Victoria Hospital,			
22	University of Ottawa	1	-	-		Montréal	1	-	-
23	Lachine General Hospital,								
	Montréal	1	-	-					
24	Children's Hospital, Montréal	1	-	-					
R.F.					R.F.				
2:21: 1	University of British Columbia	17	-	-	2:26: 1	University of Toronto	2	2	1
2	Dept. of Environment, Halifax	12	-	-	2	Clarke Institute of Psychia-			
3	Dalhousie University	6	-	-		try, Toronto	2	1	1
4	National Research Council,				3	Queen's University at Kingston	3	-	-
	Saskatoon	8	1	7	4	St. Francis Xavier University,			
5	Dept. of Environment, Vancouver	13	-	-		Antigonish	1	-	-
6	University of Toronto	8	-	-	5	York University	1	-	-
7	Dept. of Agriculture,				6	University of British Columbia	1	-	-
	Summerland, B.C.	6	-	-	7	Royal Victoria Hospital,			
8	McGill University	2	2	1		Montréal	2	-	-
9	University of Alberta	5	-	-	8	Concordia University	1	-	-
10	Dept. of Environment,				9	St. Jean de Dieu, Montréal	1	-	-
	Fredericton	3	-	-	10	University of Waterloo	1	-	-
11	University of Manitoba	5	-	-	11	University of Manitoba	1	-	-
12	Simon Fraser University	3	5	2					
13	B.C. Research Council,								
	Vancouver	2	-	-	2:27: 1	McMaster University	10	-	-
14	University of Ottawa	2	-	-	2	Chedoke Hospital, Hamilton	6	-	-
15	York University	1	-	-	3	Memorial University of			
16	Atomic Energy of Canada Ltd.,					Newfoundland	2	3	1
	Pinawa, Manitoba	4	-	-	4	Queen Mary Vet. Hospital,			
17	University of Waterloo	3	-	-		Montréal	2	1	1
18	Perkin Elmer Cdn. Ltd.,				5	McGill University	2	2	1
	Montréal	1	3	1	6	University of Western Ontario	2	-	-
19	Dept. of Environment,				7	University of Alberta	2	-	-
	Sault St. Marie	1	4	1	8	Calgary General Hospital	1	-	-
20	University of Guelph	2	-	-	9	University of Ottawa	2	-	-
21	Université du Québec	1	-	-	10	Children's Hospital, Montréal	1	-	-
22	Dept. of Agriculture, Saskatoon	1	-	-	11	Wellesley Hospital, Toronto ...	2	-	-
23	Dept. of Agriculture, London ..	1	-	-	12	Kingston General Hospital	1	-	-
24	Memorial University of				13	Queen's University at Kingston	1	-	-
	Newfoundland	1	-	-	14	Ottawa General Hospital	1	-	-
25	University of Western Ontario	1	-	-	15	Toronto Western Hospital	1	-	-
26	Dept. of Environment, Hamilton	1	-	-	16	University of Toronto	1	-	-
27	Dept. of Environment, Winnipeg	2	-	-	17	University of Alberta Hospital	1	-	-
28	Fisheries Research Board,								
	Halifax	1	-	-					
29	Ont. Ministry of Agriculture &				2:32: 1	University of Guelph	6	1	1
	Food, Guelph, Ontario	1	-	-	2	Université de Montréal	4	-	-
30	Ont. Ministry of National				3	University of Saskatchewan	4	-	-
	Resources, Delhi, Ontario ...	1	-	-	4	Dept. of Agriculture	2	-	-
					5	Unknown	1	-	-

See footnote(s) at end of table.

TABLE 7. Canadian Institutions in the Top Decile of Relevance by Research Front, 1978 Reference Year - Continued

Research front/ rank	Institution(1)	Fre- quency in top decile	Rank in top per- centile	Fre- quency in top per- centile	Research front/ rank	Institution(1)	Fre- quency in top decile	Rank in top per- centile	Fre- quency in top per- centile
R.F.					R.F.				
2:56: 1	Memorial University of Newfoundland	8	-	-	2:46: 6	University of Calgary	2	-	-
2	University of Western Ontario	2	1	1	7	University of British Columbia	2	-	-
3	University of Ottawa	3	-	-	8	Université du Québec	1	-	-
4	University of Alberta	6	-	-	9	Wellesley Hospital, Toronto ...	1	-	-
5	University of Manitoba	3	-	-	10	Dept. of Agriculture, Vancouver	1	-	-
6	Atomic Energy of Canada Ltd., Pinawa, Manitoba	2	-	-	2:56: 1	University of British Columbia	2	-	-
7	Dalhousie University	7	-	-	2	Montréal General Hospital	2	-	-
8	National Research Council, Ottawa	6	-	-	3	McGill University	4	-	-
9	Dept. of Agriculture, Sault Ste. Marie	1	-	-	4	Ontario Research Foundation, Toronto	2	-	-
10	Dept. of Environment, Vancouver	1	-	-	5	Wellesley Hospital, Toronto ...	2	-	-
11	B.C. Cancer Institute, Vancouver	1	-	-	6	Sick Children's Hospital, Toronto	2	-	-
12	University of British Columbia	1	-	-	7	Health Science Centre, Winnipeg	1	-	-
13	Brock University	1	-	-	8	Queen Mary Vet. Hospital, Montréal	1	-	-
14	University of Toronto	3	-	-	9	Atomic Energy of Canada Ltd., Chalk River, Ontario	1	-	-
15	Ontario Cancer Institute, Toronto	1	-	-	10	University of Western Ontario	2	-	-
16	University of Guelph	1	-	-	11	University of Toronto	1	-	-
17	McGill University	1	-	-	12	Foothills Hospital, Calgary ...	5	-	-
18	WW Cross Cancer Institute, Edmonton	1	-	-	13	Université de Sherbrooke Centre Hospital	1	-	-
19	Halifax Victoria General Hospital	1	-	-	14	McMaster University	1	-	-
20	University of Calgary	1	-	-	15	Montreal Neurological Hospital	1	-	-
21	Sick Children's Hospital, Toronto	1	-	-	3: 4: 1	Atomic Energy of Canada Ltd., Chalk River, Ontario	9	3	1
22	Princess Margaret Hospital, Toronto	1	-	-	2	University of British Columbia	17	-	-
23	St. Michael's Hospital, Toronto	1	-	-	3	McMaster University	9	1	6
2:39: 1	University of Toronto	7	-	-	4	Université de Montréal	2	2	2
2	University of Guelph	5	-	-	5	McGill University	5	5	1
3	University of British Columbia	2	-	-	6	University of Manitoba	4	6	1
4	McGill University	2	1	2	7	Université Laval	4	4	2
5	University of Ottawa	6	-	-	8	University of Toronto	12	7	2
6	Dept. of Environment, St. John's	2	-	-	9	Queen's University at Kingston	5	-	-
7	Université de Montréal	2	-	-	10	National Research Council, Ottawa	4	-	-
8	University of Calgary	1	-	-	11	University of Guelph	3	-	-
9	Université de Sherbrooke	1	-	-	12	University of Ottawa	1	-	-
10	Dalhousie University	2	-	-	13	Simon Fraser University	2	-	-
11	Université Laval Centre Hos- pital, Québec City	3	-	-	14	University of Western Ontario	4	-	-
12	Health and Welfare Canada, Ottawa	1	-	-	15	Carleton University	3	-	-
13	National Research Council, Halifax	1	-	-	16	University of Alberta	1	-	-
14	Dept. of Agriculture, Ottawa ..	1	-	-	17	Xerox Cdn., Toronto	1	-	-
2:40: 1	University of Alberta	1	-	-	3: 9: 1	National Research Council, Ottawa	9	2	1
2:43: 1	McMaster University	1	-	-	2	University of Toronto	20	-	-
2	Flin Flon General Hospital, Manitoba	2	-	-	3	University of Alberta	9	-	-
3	University of British Columbia	2	-	-	4	University of British Columbia	13	-	-
4	University of Toronto	2	-	-	5	University of Guelph	2	1	1
5	University of Guelph	1	-	-	6	University of New Brunswick ...	3	-	-
6	University of Alberta	4	-	-	7	Université de Montréal	5	-	-
7	Toronto General Hospital	5	-	-	8	McMaster University	2	-	-
8	Ayerst Labs., Montréal	2	-	-	9	Université Laval	3	-	-
9	Vancouver General Hospital ...	1	-	-	10	University of Western Ontario	3	-	-
10	McGill University	2	-	-	11	University of Windsor	3	-	-
11	Douglas Hospital, Montréal	1	-	-	12	University of Manitoba	1	-	-
2:44: 1	Sick Children's Hospital, Toronto	4	-	-	13	Université de Sherbrooke	2	-	-
2	University of Toronto	3	-	-	14	Simon Fraser University	2	-	-
3	McGill University	1	-	-	15	York University	1	-	-
4	Royal Victoria Hospital, Montréal	1	-	-	3:10: 1	University of Toronto	19	1	4
5	University of Manitoba	1	-	-	2	National Research Council, Ottawa	14	2	4
2:46: 1	McGill University	3	1	1	3	Atomic Energy of Canada Ltd., Chalk River, Ontario	9	4	2
2	University of Toronto	6	-	-	4	University of Windsor	3	3	1
3	University of Western Ontario	2	-	-	5	University of British Columbia	14	-	-
4	Ontario Cancer Institute, Toronto	3	-	-	6	University of Saskatchewan	3	5	2
5	University of Manitoba	1	2	1	7	Université Laval	9	-	-
					8	Queen's University at Kingston	5	6	1
					9	McMaster University	14	9	2
					10	Trent University	2	7	2
					11	University of Western Ontario	8	8	5
					12	University of Alberta	4	-	-
					13	University of Waterloo	11	-	-
					14	Université de Montréal	9	10	2
					15	University of Manitoba	3	11	1
					16	McGill University	2	-	-

See footnote(s) at end of table.

TABLE 7. Canadian Institutions in the Top Decile of Relevance by Research Front, 1978 Reference Year - Continued

Research front/ rank	Institution(1)	Fre- quency in top decile	Rank in top per- centile	Fre- quency in top per- centile	Research front/ rank	Institution(1)	Fre- quency in top decile	Rank in top per- centile	Fre- quency in top per- centile
R.F.					R.F.				
3:10:17	Dalhousie University	1	-	-	4: 3:25	Pulp and Paper Research Institute, Montréal	1	-	-
18	Barringer Research Ltd., Toronto	1	-	-	26	Cdn. Packers Ltd., Toronto	1	-	-
19	University of Ottawa	1	12	1	27	Université de Moncton	1	-	-
20	Université de Moncton	1	-	-					
21	York University	3	-	-	5:11: 1	University of Calgary	21	-	-
22	Bowmar Cdn. Ltd., Ottawa	1	-	-	2	University of Toronto	7	-	-
23	Linear Tech. Inc., Hamilton ...	1	-	-	3	National Research Council, Saskatoon	7	-	-
24	Simon Fraser University	1	-	-	4	University of Western Ontario	3	-	-
25	FMC Cdn. Ltd., Squamish, B.C.	1	-	-	5	University of Guelph	3	-	-
26	Université du Québec	1	-	-	6	McMaster University	3	-	-
27	Dept. of National Defence, Québec City	1	-	-	7	Queen's University at Kingston	3	1	1
28	Unican Electrochem. Prod., Montréal	1	-	-	8	University of Alberta	1	-	-
29	Xerox Cdn., Toronto	1	-	-	9	Simon Fraser University	1	-	-
					10	Dept. of Agriculture, Ottawa ..	2	-	-
3:14: 1	Dept. of Environment, Wolfville, N.S.	20	1	6	11	Dept. of Environment, Fredericton	1	-	-
2	Dalhousie University	17	-	-	12	Dept. of Agriculture, London, Ontario	2	-	-
3	Dept. of Agriculture, Ottawa ..	9	-	-	13	Carleton University	1	-	-
4	Health and Welfare Canada, Ottawa	6	3	1	14	University of British Columbia	1	-	-
5	University of Waterloo	10	-	-	15	University of New Brunswick ...	1	-	-
6	University of Alberta	5	-	-	16	University of Saskatchewan	1	-	-
7	Dept. of Environment, Halifax	3	-	-	17	Dept. of Agriculture, Windsor	1	-	-
8	Université de Moncton	6	-	-					
9	McGill University	3	-	-	5:20: 1	National Research Council, Ottawa	7	3	1
10	University of Toronto	3	-	-	2	University of Guelph	8	2	2
11	University of Manitoba	2	2	2	3	University of British Columbia	5	-	-
12	Gulf Oil Canada Ltd., Toronto	1	-	-	4	University of Waterloo	2	1	2
13	Alberta Research Council, Edmonton	1	-	-	5	Concordia University	3	-	-
14	National Research Council, Ottawa	1	-	-	6	University of Western Ontario	6	-	-
15	Dept. of Agriculture, Winnipeg	1	-	-	7	University of Manitoba	2	4	2
16	Dept. of Environment, Vancouver	1	-	-	8	University of Alberta	2	-	-
17	Dept. of Environment, Sault Ste. Marie	2	-	-	9	University of Saskatchewan	2	-	-
18	Ont. Ministry of Environment, Toronto	3	-	-	10	University of Toronto	2	5	2
19	Energy, Mines and Resources, Ottawa	2	-	-	11	University of Calgary	3	-	-
20	University of Saskatchewan	3	-	-	12	Dept. of National Defence, Ottawa	1	-	-
21	Memorial University of Newfoundland	4	-	-	13	Ayerst Labs., Montréal	1	-	-
22	Dept. of Environment, Winnipeg	2	-	-	14	Queen's University at Kingston	1	-	-
23	University Hospital of Saskatchewan, Saskatoon	3	-	-	15	Xerox Cdn., Toronto	1	-	-
24	Carleton University	3	-	-					
25	Health and Welfare Canada, Halifax	1	-	-	5:25: 1	Carleton University	1	-	-
26	Ayerst McKenna & Harrison, Montréal	1	-	-	2	University of Guelph	1	-	-
					3	McGill University	2	-	-
4: 3: 1	University of Alberta	39	1	9	4	Queen's University at Kingston	1	-	-
2	University of Toronto	34	-	-	5	Université de Sherbrooke	1	-	-
3	University of Western Ontario	20	2	5					
4	University of Ottawa	15	-	-	5:29: 1	Dept. of Agriculture, London	10	-	-
5	University of Waterloo	10	-	-	2	Dept. of Agriculture, Charlottetown	8	-	-
6	Queen's University at Kingston	11	-	-	3	University of Guelph	6	-	-
7	McGill University	14	-	-	4	University of Alberta	2	2	1
8	University of British Columbia	12	-	-	5	University of Saskatchewan	5	-	-
9	University of Guelph	10	-	-	6	Brock University	1	1	1
10	McMaster University	4	3	2	7	Dept. of Agriculture, Lennoxville, Québec	1	-	-
11	University of Windsor	6	-	-	8	Dept. of Agriculture, Fredericton	1	-	-
12	University of Manitoba	2	4	1	9	National Research Council, Saskatoon	4	-	-
13	Simon Fraser University	8	-	-	10	Dept. of Agriculture, Swift Current, Saskatchewan	1	-	-
14	National Research Council, Ottawa	5	-	-	11	York University	2	-	-
15	Dalhousie University	2	-	-	12	Dept. of Agriculture, Wolfville, N.S.	1	-	-
16	University of Saskatchewan	5	-	-	13	Dept. of Agriculture, Winnipeg	1	-	-
17	Université de Montréal	2	-	-					
18	Bristol Labs. Cdn., Montréal	2	-	-	6:17: 1	University of British Columbia	1	1	1
19	Dept. of Environment, Fredericton	3	-	-	2	Dalhousie University	1	-	-
20	Université de Sherbrooke	2	-	-	3	University of Toronto	1	-	-
21	York University	3	-	-					
22	University of Calgary	3	-	-	6:30: 1	McGill University	2	-	-
23	Concordia University	1	-	-	2	Energy, Mines and Resources, Ottawa	2	-	-
24	Lakehead University, Thunder Bay	1	-	-					

See footnote(s) at end of table.

TABLE 7. Canadian Institutions in the Top Decile of Relevance by Research Front, 1978 Reference Year - Continued

Research front/ rank	Institution(1)	Fre- quency in top decile	Rank in top per- centile	Fre- quency in top per- centile	Research front/ rank	Institution(1)	Fre- quency in top decile	Rank in top per- centile	Fre- quency in top per- centile
R.F.					R.F.				
6:30: 3	Atomic Energy of Canada Ltd., Chalk River, Ontario	6	-	-	9:23: 1	Université Laval	2	-	-
4	Dept. of Environment, Vancouver	1	-	-	2	National Research Council, Ottawa	4	-	-
6:57: 1	University of Toronto	4	-	-	3	University of Toronto	2	-	-
2	National Research Council, Ottawa	1	-	-	4	Université du Québec	3	-	-
3	Dalhousie University	1	-	-	5	University of Waterloo	1	-	-
4	University of British Columbia	1	-	-	6	Concordia University	1	-	-
5	Dept. of National Defence, Toronto	1	-	-	9:31: 1	University of Saskatchewan	2	-	-
7:34: 1	National Research Council, Ottawa	3	-	-	2	University of Alberta	2	-	-
2	University of Ottawa	6	-	-	3	National Research Council, Ottawa	3	-	-
3	University of British Columbia	12	-	-	4	University of British Columbia ..	1	-	-
4	University of Waterloo	3	-	-	5	Dept. of Communication, Ottawa ..	1	-	-
5	University of Alberta	7	-	-	9:42: 1	Queen's University at Kingston ..	1	1	1
6	Université de Sherbrooke	1	2	1	2	University of Alberta	3	2	3
7	Dept. of Environment, Ottawa ..	1	-	-	3	Dept. of Environment, Halifax ..	2	3	2
8	Nova Scotia Technical College, Halifax	2	-	-	4	Dept. of Environment, Hamilton ..	6	-	-
9	McGill University	2	-	-	5	Dept. of Agriculture, Ottawa ..	2	-	-
10	Queen's University at Kingston ..	1	-	-	6	Acadia University, Wolfville, N.S.	3	-	-
11	Université de Montréal	1	-	-	7	National Research Council, Ottawa	2	-	-
12	McMaster University	2	-	-	8	Dept. of Agriculture, Wolfville, N.S.	1	-	-
13	Université Laval	4	-	-	9:48: 1	Dept. of Environment, Toronto ..	1	-	-
14	University of Calgary	3	-	-	2	McGill University	2	-	-
15	Synchrude Cdn. Ltd., Edmonton ..	1	-	-	3	Dept. of Environment, Montréal ..	1	-	-
7:41: 1	University of Ottawa	3	1	3	9:81: 1	Energy, Mines and Resources, Ottawa	4	-	-
2	University of Toronto	7	2	2	2	University of Toronto	2	-	-
3	National Research Council, Ottawa	3	-	-	3	McGill University	2	-	-
4	University of Alberta	1	-	-	4	Saskatchewan Research Council, Saskatoon	1	-	-
5	University of Waterloo	3	-	-	5	Queen's University at Kingston ..	1	-	-
6	Atomic Energy of Canada Ltd., Chalk River, Ontario	6	-	-	10:38: 1	University of Waterloo	3	1	2
7	University of Guelph	2	-	-	2	Carleton University	2	2	1
8	Royal Military College, Kingston	1	-	-	3	University of British Columbia ..	4	-	-
9	Brock University	1	-	-	4	Lakehead University at Sudbury ..	3	-	-
7:51: 1	University of Western Ontario ..	1	1	1	5	University of Saskatchewan	1	3	1
2	McMaster University	2	-	-	6	Memorial University of New- foundland	1	-	-
7:53: 1	Inst. Rec. Hydro Québec, Montréal	1	-	-	7	University of Manitoba	3	-	-
2	University of Alberta	2	-	-	8	Dept. of Agriculture, Saskatoon	1	-	-
3	University of Western Ontario ..	2	-	-	9	Queen's University at Kingston ..	1	-	-
4	University of Windsor	1	-	-	10	Dept. of Environment, Edmonton ..	1	-	-
5	National Research Council, Ottawa	1	-	-	11	Université Laval	1	-	-
6	University of British Columbia ..	1	-	-	12	Dept. of Environment, Fredericton	2	-	-
7:79: 1	University of New Brunswick ...	1	-	-	13	University of New Brunswick ...	1	-	-
2	McGill University	1	-	-	14	Dept. of Environment, Ottawa ..	1	-	-
3	McMaster University	2	-	-	15	Ontario Research Foundation, Toronto	1	-	-
4	Noranda, Montréal	1	-	-	10:45: 1	University of Alberta	1	1	1
8:13: 1	University of Toronto	11	-	-	2	University of Manitoba	2	-	-
2	Energy, Mines and Resources, Victoria	9	1	1	3	Ontario Ministry of Solicitor General, Barrie, Ontario	2	-	-
3	Energy, Mines and Resources, Ottawa	8	-	-	4	University of Guelph	1	-	-
4	Memorial University of New- foundland	5	-	-	5	York University	1	-	-
5	University of Western Ontario ..	3	-	-	6	University of Toronto	2	-	-
6	University of Alberta	4	-	-	7	Dalhousie University	2	-	-
7	National Research Council, Ottawa	2	-	-	10:49: 1	University of Saskatchewan	1	1	1
8	Queen's University at Kingston ..	3	-	-	2	University of British Columbia ..	2	-	-
9	University of British Columbia ..	2	-	-	3	National Research Council, Saskatoon	1	-	-
10	Université de Montréal	2	-	-	4	Dept. of Environment, Fredericton	1	-	-
11	Université Laval	1	-	-	5	York University	3	-	-
12	University of Calgary	1	-	-	6	Dept. of Agriculture, Swift Current, Saskatchewan ..	1	-	-
13	York University	2	-	-					

See footnote(s) at end of table.

TABLE 7. Canadian Institutions in the Top Decile of Relevance by Research Front, 1978 Reference Year - Concluded

Research front/ rank	Institution(1)	Fre- quency in top decile	Rank in top per- centile	Fre- quency in top per- centile	Research front/ rank	Institution(1)	Fre- quency in top decile	Rank in top per- centile	Fre- quency in top per- centile
R.F.					R.F.				
10:50:	1 Dept. of Agriculture, Ottawa ..	16	1	3	13:37:	1 University of Toronto	3	-	-
	2 University of Alberta	13	2	1		2 Sick Children's Hospital, Toronto	3	-	-
	3 McMaster University	6	-	-		3 Princess Margaret Hospital, Toronto	1	-	-
	4 University of Western Ontario ..	3	3	1		4 Royal Victoria Hospital, Montréal	2	-	-
	5 University of British Columbia ..	4	-	-		5 McGill University	2	-	-
	6 University of Guelph	2	-	-		6 Jewish General Hospital, Montréal	3	-	-
	7 National Health and Welfare, Ottawa	4	-	-		7 Wellesley Hospital, Toronto ...	1	-	-
	8 University of Saskatchewan	1	-	-					
	9 University of Waterloo	2	-	-	14:47:	1 University of Victoria	2	1	1
	10 University of Wilfrid Laurier	1	4	1		2 University of Toronto	6	-	-
	11 University of Toronto	2	-	-		3 Simon Fraser University	3	-	-
	12 University of Manitoba	4	-	-		4 Ontario Hydro, Toronto	4	-	-
	13 Dept. of Agriculture, Lennoxville, Québec	1	-	-		5 University of Waterloo	2	-	-
	14 Dept. of Agriculture, Swift Current, Saskatchewan ..	1	-	-		6 McGill University	2	-	-
	15 Dept. of Agriculture, Hull, Québec	1	-	-		7 University of Alberta	1	-	-
	16 McGill University	1	-	-		8 University of Calgary	1	-	-
	17 Dept. of Agriculture, Edmonton ..	2	-	-		9 McMaster University	1	-	-
	18 Université Laval	1	-	-		10 University of British Columbia ..	1	-	-
	19 Québec Minister Agriculture, Québec City	1	-	-		11 Université de Montréal	1	-	-
	20 Dept. of Agriculture, Fredericton	1	-	-	14:82:	1 École Polytechnique, Montréal ..	1	-	-
	21 Vancouver General Hospital	1	-	-		2 York University	1	-	-
						3 University of British Columbia ..	1	-	-
10:54:	1 Memorial University of New- foundland	3	-	-	15:35:	1 University of Toronto	2	-	-
	2 Brock University	2	-	-		2 University of British Columbia ..	1	-	-
	3 Dept. of Environment, St. John's	1	-	-		3 University of Manitoba	1	-	-
	4 National Research Council, Halifax	1	-	-		4 National Research Council, Ottawa	1	-	-
10:61:	1 University of Alberta	3	-	-	17:59:	1 Dept. of Environment, Ottawa ..	1	1	1
	2 McGill University	1	-	-		2 University of British Columbia ..	1	2	1
	3 University of Regina	1	-	-		3 University of Toronto	1	-	-
	4 Dept. of Agriculture, Windsor ..	1	-	-					
10:63:	1 Dept. of Agriculture, Windsor ..	4	-	-	20:65:	1 University of British Columbia ..	1	1	1
	2 Dept. of Agriculture, Summerland, B.C.	1	-	-		2 York University	1	-	-
	3 University of Guelph	1	-	-					
11:18:	1 McGill University	7	1	4	22:68:	1 Dept. of Agriculture	4	1	4
	2 Montréal Neurological Hospital ..	4	2	2		2 University of Guelph	2	2	2
	3 University of British Columbia ..	5	-	-		3 University of Saskatchewan	3	-	-
	4 University Hospital, London ...	4	-	-		4 Ont. Min. Agr. & Food, Guelph, Ontario	1	-	-
	5 University of Toronto	5	-	-	23:72:	1 Memorial University of Newfoundland	2	-	-
	6 University of Alberta	2	-	-		2 University of Alberta	4	1	4
	7 Sunnybrook Hospital, Toronto ..	4	-	-		3 University of British Columbia ..	2	2	2
	8 Université de Montréal	3	-	-		4 Concordia University	2	-	-
	9 Toronto Western Hospital	2	-	-		5 University of Calgary	1	-	-
	10 National Health and Welfare, Ottawa	2	-	-		6 McGill University	1	-	-
	11 Royal Victoria Hospital, Montréal	1	3	1		7 Queen Mary Vet. Hospital, Montréal	1	-	-
	12 Montréal General Hospital	1	-	-	24:73:	1 University of Alberta	4	-	-
	13 Centre of Forensic Science, Toronto	2	-	-		2 Dept. of Agriculture, Delhi, Ontario	1	-	-
	14 Wellesley Hospital, Toronto ...	1	-	-		3 University of Guelph	1	-	-
	15 Notre Dame Hospital, Manitoba ..	1	-	-		4 Dept. of Agriculture, Ottawa ..	3	-	-
	16 Maisonneuve Rosemont Hospital, Montréal	1	-	-		5 Dept. of Agriculture, Montréal ..	3	-	-
	17 Inst. Armand Frappier, Montréal	1	-	-					
	18 McMaster University	1	-	-					
	19 Medical Research Council, Hamilton	1	-	-					
	20 Hotel Dieu, Montréal	1	-	-					
11:22:	1 McGill University	1	-	-					

(1) All institutional addresses were assigned to census areas; i.e., they do not represent mailing addresses.

Appendix VI

INDEX TO RELEVANT JOURNALS

Journal	Field	Front	Journal	Field	Front	Journal	Field	Front
A GRAEFES A	13	22	ADV PARASIT	10	54	ANGEW MAKRO	7	51
A VAN LEEUW	2	39	ADV PHYS O	7	34	ANGIOLOGY	2	43
AAPG BULL	8	13	ADV PHYSICS	3	10	ANIM BEHAV	10	38
ACC CHEM RE	3	9	ADV POLYM S	7	51	ANIM LEAR B	10	45
ACC REVIEW	14	55	ADV PROTEIN	2	12	ANIM PRODUC	10	50
ACT ALLERG	2	56	ADV VIRUS R	2	46	ANN ALLERGY	2	56
ACT ANAE SC	2	44	AGENT ACTIO	2	43	ANN AP BIOL	5	29
ACT ANATOM	2	24	AGR BIOL CH	2	39	ANN BIOL AN	30	70
ACT BIO MED	23	72	AGRON J	5	29	ANN BOTANY	5	11
ACT BIOCH P	23	72	AIAA J	6	30	ANN CHIM	7	34
ACT BOT NEE	10	49	AICHE J	7	34	ANN CHIR	2	56
ACT CARDIOL	2	56	AM BAR A J	16	33	ANN CLIN R	2	56
ACT CHEM B	7	51	AM CRIM LAW	14	52	ANN ENDOCR	2	46
ACT CHIM H	7	34	AM ECON REV	10	28	ANN ENT S A	2	21
ACT CHIR SC	2	19	AM EDUC RES	2	40	ANN GENET	2	24
ACT CRYST A	3	9	AM HEART J	1	2	ANN GEOPHYS	9	31
ACT CRYST B	3	9	AM IND HYG	9	42	ANN HUM GEN	2	24
ACT CYTOL	2	46	AM J ANAT	1	6	ANN IMMUNOL	2	46
ACT DER-VEN	2	27	AM J BOTANY	5	11	ANN INT MED	1	2
ACT ENDOCR	1	8	AM J CARD	1	2	ANN MATH	6	17
ACT HAEMAT	2	19	AM J CLIN N	2	19	ANN MED IN	2	36
ACT HISTOCH	2	46	AM J CLIN P	1	5	ANN MU BOT	10	49
ACT MATH	6	17	AM J DIG DI	1	7	ANN NY ACAD	1	2
ACT MED SC	1	8	AM J DIS CH	1	8	ANN OTOL RH	13	37
ACT METALL	3	10	AM J EPIDEM	2	19	ANN PHYSICS	3	4
ACT NEUR SC	11	18	AM J GASTRO	2	36	ANN PHYSIK	9	23
ACT NEUROB	23	72	AM J HU GEN	2	24	ANN PHYSIO	7	53
ACT NEUROCH	10	50	AM J MATH	6	17	ANN PROBAB	14	82
ACT NEUROP	11	18	AM J MED	1	2	ANN R ASTRO	8	13
ACT OBST SC	2	46	AM J MED SC	1	8	ANN R BIOCH	1	6
ACT ODON SC	15	35	AM J MENT D	20	65	ANN R BIOPH	2	24
ACT OPTH K	13	22	AM J OBST G	1	8	ANN R ECOL	10	38
ACT ORTH SC	10	50	AM J OPTH	13	22	ANN R ENTUM	2	21
ACT OTO-LAR	13	37	AM J ORTHOP	2	26	ANN R GENET	2	24
ACT PAED SC	2	19	AM J PATH	1	5	ANN R MED	2	27
ACT PAT S A	2	46	AM J PHYS	7	53	ANN R MICRO	2	15
ACT PAT S B	2	32	AM J PHYSL	1	2	ANN R NUCL	9	23
ACT PHARM T	3	14	AM J PSYCHI	2	26	ANN R PH CH	5	20
ACT PHY P A	7	53	AM J PSYCHO	2	26	ANN R PHARM	3	14
ACT PHYS AU	7	53	AM J PSYCHT	10	45	ANN R PHYSL	2	24
ACT PHYSL S	1	5	AM J PUB HE	2	19	ANN R PHYTO	5	29
ACT PSYC SC	2	26	AM J ROENTG	1	7	ANN R PLANT	5	11
ACT PSYCHOL	10	45	AM J SCI	8	13	ANN R PSYCH	10	45
ACT RAD DGN	2	36	AM J SOCIOL	2	40	ANN RADIOLOG	2	56
ACT RAD TPB	2	56	AM J SURG	1	7	ANN RC SURG	2	43
ACT VET SC	22	68	AM J TROP M	2	19	ANN RHEUM D	2	27
ACT VIROLOG	2	46	AM J VET RE	2	32	ANN SCI N Z	10	54
ACUSTICA	6	57	AM MATH MO	14	47	ANN STATIST	10	50
ADM SCI QUA	2	40	AM MIDL NAT	2	21	ANN SURG	1	7
ADV AGRON	10	50	AM MINERAL	8	13	ANN THORAC	2	19
ADV ATON M	7	41	AM NATURAL	2	21	ANN TROP M	2	19
ADV CANC R	2	36	AM POLI SCI	2	40	ANTIM AG CH	1	8
ADV CARB C	2	39	AM PSYCHOL	2	12	APPL OPTICS	3	10
ADV CATAL	7	34	AM R RESP O	1	8	APPL PHYS	7	41
ADV CHEM SE	5	20	AM SCIENT	10	38	APPL PHYS L	3	4
ADV CY NU R	2	24	AM SOCIOL R	2	40	APPL SPECTR	9	42
ADV ENZYM	2	12	AM SURG	2	19	ARCH ANAT M	2	46
ADV ENZYME	2	39	AM ZOOLOG	2	12	ARCH BIOCH	1	1
ADV GENETIC	10	49	ANAESTHESIA	2	44	ARCH DERMAT	2	27
ADV HETERO	7	34	ANAL LETTER	9	42	ARCH DIS CH	1	8
ADV IMMUNOL	2	27	ANALYST	3	14	ARCH EISENH	7	79
ADV INORG C	7	34	ANALYT BIOC	1	2	ARCH ENV HE	3	14
ADV LIPID R	10	50	ANALYT CHEM	3	14	ARCH FR PED	2	36
ADV MATH	14	47	ANALYT CHIM	3	14	ARCH G PSYC	2	26
ADV MICROB	2	39	ANAT REC	1	6	ARCH HIST J	2	46
ADV NEUROL	2	36	ANNESTHESIO	2	44	ARCH HYDROB	10	38
ADV ORGMET	7	34	ANGEW CHEM	4	3	ARCH I PHAR	1	5

INDEX TO RELEVANT JOURNALS - Continued

Journal	Field	Front	Journal	Field	Front	Journal	Field	Front
ARCH I PHYS	2	39	BIOC PHY PF	10	49	CAN J COM M	2	32
ARCH IN MED	1	2	BIOCH PHARM	1	5	CAN J EARTH	8	13
ARCH IT BIO	2	36	BIOCH SOC T	2	24	CAN J ECON	14	55
ARCH MAL C	2	56	BIOCHEM	1	1	CAN J GENET	2	24
ARCH MATH	14	47	BIOCHEM GEN	2	24	CAN J MATH	6	17
ARCH MIKROB	2	15	BIOCHEM J	1	1	CAN J MICRO	2	15
ARCH NEUROL	11	18	BIOCHEM MED	2	39	CAN J PHYS	3	10
ARCH OPTH	13	22	BIOCHEMIE	2	24	CAN J PHYSL	3	14
ARCH ORAL B	15	35	BIOFIZIKA	23	72	CAN J PLANT	5	29
ARCH ORTHO	10	50	BIOL B	2	12	CAN J PSYCH	10	45
ARCH OTOLAR	13	37	BIOL NEONAT	10	50	CAN J SOIL	10	50
ARCH PATH	1	5	BIOL PSYCHI	10	45	CAN J SURG	2	43
ARCH PHARM	7	34	BIOL REPROD	1	8	CAN J ZOOL	2	21
ARCH PSYCHI	10	50	BIOL REV	2	24	CAN MED A J	1	8
ARCH R MECH	6	30	BIOL ZBL	10	49	CAN METAL Q	7	79
ARCH SURG	1	7	BIOMEDICINE	2	46	CAN PSYCHI	10	45
ARCH VIROL	2	46	BIOMETRICS	10	50	CAN VET J	22	68
ARCH ZOOL E	10	54	BIOMETRIKA	10	50	CANCER	1	2
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AUK	10	38	BOTAN REV	5	29	CELL TISS K	2	36
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- 88-502E International Payments and Receipts for Technology
- 88-503E Technology and Commodity Trade
- 88-504E Patents as Indicators of Invention
- 88-505E Industrial Productivity and Research and Development Indicators
- 88-506E A Framework for Measuring Research and Development Expenditures in Canada
- 88-507E An Indicator of Excellence in Canadian Science: Summary Report
- 88-508E Human Resources for Science and Technology (forthcoming)

These publications are also available in French.

Statistical reports for most indicator series are being developed for annual publication by Statistics Canada. Existing publications are listed below.

STATISTICAL PUBLICATIONS

Catalogue

- 88-001 Science Statistics, Monthly
- 88-201 Science and Technology Indicators, Annual
- 88-202 Industrial Research and Development Statistics, Annual
- 88-203 Resources for Research and Development in Canada, Annual
- 88-204E Federal Scientific Activities, Annual
- 88-205E Industrial Research and Development Facilities, Annual

